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THESIS

MANAGEMENT OF DEMAND BASED INVENTORY
ABOARD SUBMARINE TENDERS SERVICING
ATTACK (SSN) SUBMARINES

by

Timothy Joseph Ross

December 1990

Thesis Advisor: Alan W. McMasters

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Management of Demand Based Inventory Aboard Submarine Tenders Servicing Attack (SSN) Submarines

by

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Lieutenant, Supply Corps, United States Navy
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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis examines the computation of inventory levels based on demand history aboard Submarine Tenders that use the Shipboard Automated Data Processing System (SUADPS) for inventory control. The focus of the thesis was the workload and supply effectiveness issues associated with the processing of the SUADPS levels setting program. The objective of the thesis was to determine the effect on supply effectiveness and stock churn if the levels program was processed less frequently. The thesis concludes that the likely effect of less frequent processing of the levels setting program would be an insignificant decrease in supply effectiveness and a significant decrease in stock churn. Further research involving a review of the assumptions and procedures of the SUADPS inventory model was recommended.

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TABLE OF CONTENTS

I. INTRODUCTION ---------- 1

A. BACKGROUND ---------- 1

B. OBJECTIVE ---------- 3

C. SCOPE ---------- 3

D. ORGANIZATION ---------- 4

II. BACKGROUND AND LITERATURE REVIEW ---------- 6

A. INVENTORY MANAGEMENT IN SUADPS ---------- 6

B. SHIPBOARD CONTROL OF LEVELS PARAMETERS ----- 13

C. TYPE COMMANDER DIRECTED LEVELS PARAMETERS -- 15

D. WORKLOAD ISSUES OF LEVELS PROCESSING ------- 16

E. EFFECTIVENESS ISSUES OF LEVELS PROCESSING -- 19

F. REVIEW OF PREVIOUS STUDIES ---------- 20

III. ANALYSIS METHODOLOGY ---------- 27

A. OBJECTIVES OF THE ANALYSIS METHODOLOGY ----- 27

B. EFFECTS OF LEVELS PROCESSING FREQUENCY ON SUPPLY EFFECTIVENESS ---------- 27

C. EFFECTS OF LEVELS PROCESSING FREQUENCY ON STOCK CHURN ---------- 29

D. SOURCES OF DATA ---------- 29

E. STRUCTURE OF THE ANALYSIS METHODS ---------- 33

F. RANGE SIMULATION ---------- 33

G. DEPTH SIMULATION ---------- 38

IV. RESULTS OF THE ANALYSES ---------- 43

A. RESULTS OF RANGE SIMULATION ---------- 43

B. INTERPRETATION OF RANGE SIMULATION RESULTS - 52

C. RESULTS OF DEPTH SIMULATION ---------- 57

D. INTERPRETATION OF DEPTH SIMULATION RESULTS - 59

E. ANALYSIS OF THE DEMAND FORECASTING METHODS - 64

V. CONCLUSIONS AND RECOMMENDATIONS ---------- 76

A. SUMMARY ---------- 76

B. CONCLUSIONS ---------- 76

C. RECOMMENDATIONS ---------- 78

LIST OF REFERENCES ---------- 81

INITIAL DISTRIBUTION LIST ---------- 82

I. INTRODUCTION

A. BACKGROUND

The general area of research of this study is the management of demand based consumer level retail inventories. Consumer level inventories are stocks of secondary items held below the intermediate retail level "by the final element in an established distribution system for the sole purpose of internal consumption or utilization." [Ref. 1]. The demand based portion of these inventories consist of those items stocked based on locally recorded demand rather than other criteria such as equipment essentiality or mission criticality.

The specific focus of this study is the management of demand based retail inventories held aboard submarine tenders (AS) utilizing the inventory control functions of the Shipboard Automated Data Processing System (SUADPS). These stocks are held to support the operation of the tender maintenance activity and assigned submarines. Issues addressed in this study are also relevant to some degree to the management of retail stocks held aboard other ships equipped with SUADPS. SUADPS is also installed aboard destroyer tenders (AD), repair ships (AR) and combat stores ships (AFS). An aviation support version (SUADPS-AV) is

installed aboard aircraft carriers (CV,CVN), some amphibious ships (LPH,LHA) and Marine Air Groups (MAG).

The program within SUADPS that manages inventory levels of demand based items is called the Demand History Processing program, also referred to as "levels." This program reviews demand data recorded for items in the master record file (MRF), forecasts future demand from this data, and uses the forecast in setting two inventory action points. The first of these is the requisitioning objective (RO) or high limit, and the second is the reorder point (RP). In addition, the levels program changes allowance type (AT) codes as necessary and deletes entire MRF records when they are no longer required.

Processing of the levels program initiates several actions by inventory control and storage personnel aboard ship. These actions include:

- Initiation of stock reorders and cancellation of outstanding stock orders based on new values of ROs and RPs.
- Management analysis of output reports to identify abnormal or undesired stock level actions.
- Manual correction or reversal of program actions required by exceptional or erroneous demand recording.
- Physical counting of items for which the MRF record has been deleted.
- Off load and turn in of material identified as excess due to changes in ROs and deletions from the MRF.

The frequency of reviewing stock levels by running the levels program is prescribed by the Type Commander for each

ship. The current requirement for submarine tenders under the command of Commander Submarine Forces Atlantic (COMSUBLANT) is to run the levels program at least monthly and after processing of a change to the tender load list. It is this monthly requirement that is the central issue of this study.

B. OBJECTIVE

The objective of this thesis is to answer the following questions:

- Given the workload demands placed on shipboard personnel by processing of levels, can the frequency of processing be reduced without adversely affecting supply effectiveness?
- What is the effect on churn, or the number of additions and deletions to the demand based stock battery, as the levels processing frequency is varied?

C. SCOPE

This study will focus on the processing of the levels program as practiced aboard COMSUBLANT submarine tenders servicing attack (SSN) submarines. The computations and procedures used in this analysis are not applicable to submarine tenders servicing fleet ballistic missile (SSBN) submarines. The parameters used in computing stock depth and range in this analysis are in accordance with COMSUBLANT guidance [Ref. 2].

Stock levels computed in this analysis will reflect the effect of demand history only. The effects of other stock

allowance factors such as COSAL, load list etc., were not considered.

Demand data for this study were obtained in monthly summary form from the MRF records of the USS Frank Cable (AS-40). Due to a combination of data processing capability and time constraints it was not feasible to collect individual transaction and unit price data in a form which would facilitate a complete computer simulation. This was due to two major factors. The first is the difference in operating characteristics between the SUADPS hardware aboard ship and the computer resources available to the author. The second is the nature in which individual transaction data are stored in shipboard records. Resolution of these problems could not be accomplished within the time available for this study. The impact of the data format on the design and limitations of the analysis methods used in this study are discussed in detail in a later chapter.

D. ORGANIZATION

The remainder of this thesis is divided into four major chapters:

- Chapter II discusses the SUADPS levels setting process and the workload and effectiveness issues involved. This chapter will also review previous research efforts in this area.
- Chapter III describes the analysis methodology. This includes data availability, measures of effectiveness and the assumptions of the simulation model used.

- Chapter IV presents the results of the simulation and a discussion of them.

- Chapter V summarizes the thesis effort, and presents conclusions and recommendations based on the analysis results. In addition, areas for further research will be identified.

II. BACKGROUND AND LITERATURE REVIEW

A. INVENTORY MANAGEMENT IN SUADPS

SUADPS provides an automated means for performing routine supply support functions such as posting of issues and receipts, recording quantities and frequency of demand and processing orders for stock and direct turn over material. In addition, SUADPS provides reports to assist managers in controlling the level and accuracy of shipboard stocks [Ref. 3].

The primary tool used in management of stock levels aboard SUADPS ships is the Demand History Processing program, commonly referred to as "levels." This program not only sets inventory action points for demand based items but also provides a tool for inventory control personnel aboard ship to review and analyze changes in the stock load caused by demand trends or other administrative actions such as changes to the tender load list.

Processing of the levels program involves the interaction of many different factors and parameters. The nature of the relationship between these variables has been the subject of previous research efforts in this area. Key concepts and terms related to levels processing are defined below. The reference for all SUADPS definitions is NAVSUP publication 522 [Ref. 4]. The reference for COMSUBLANT

specific guidance and criteria is the Tender Supply Management Instruction [Ref. 2].

1. Master Record File

The master record file (MRF) contains the record of all items stocked aboard ship as well as records for items not stocked but that have recorded demand. Each MRF record contains key data elements such as National Stock Number (NSN), unit price, on hand and on order quantities, allowance quantities, requisitioning objective (RO) and reorder point (RP). In addition, MRF records contain up to 24 months of demand history and the most recent computation of average monthly demand.

2. Allowance Type Codes

Allowance type (AT) codes are assigned to MRF records to indicate the justification for stocking a particular item. One function of the levels program is to update AT codes when appropriate based on the presence or absence of certain allowance data elements in the MRF records. A listing of AT codes used aboard COMSUBLANT tenders and their associated stocking justifications is provided below.

AT CODE	STOCKING JUSTIFICATION
1	COSAL Allowed Item.
2	Tender Load List Item.
3	Item with both COSAL and Load List allowance.
4	Item stocked based on DBI criteria only (explained below).
5	TYCOM authorized load quantity.
6	Item considered excess based on range criteria.
7	Item considered excess based on range criteria, but with an extended dollar value (unit price x quantity) less than or equal to the economic retention factor input to levels (currently fixed by COMSUBLANT at $100.00).
8	Item not allowed for stock but with recorded demand in the last 12 months. MRF record established for demand record only.
9	Item carried as substitute for another allowed item.

3. Demand Based Items

Items which experience sufficient demand frequency based on TYCOM criteria are designated as demand based items (DBI). These items are also referred to as peacetime operating stock, or "POS" items. The current COMSUBLANT criteria for qualification as a DBI is a requisition frequency of two or more in the last six months. To retain an item in stock based only on demand it must experience a requisition frequency of two or more in the last 12 months. Items carried in stock based on other criteria such as being part of the load list or COSAL and which meet DBI criteria

will have POS levels of inventory authorized independent of these other stocking allowances.

Items designated as DBI are indicated with the setting of a "POS" flag on their MRF record. As shown above, items stocked solely based on DBI qualification are designated allowance type code 4. An item stocked as AT codes 1, 2, 3, or 5 may also qualify as DBI and the computations of that item's RO and RP will then be a function of both the DBI formulas and allowance quantities. In such cases the allowance quantities act as lower bounds on the computed DBI safety level.

4. Recording and Computation of Demand

The frequency and quantity of demand are recorded in the demand history sub-records of each MRF record. A sub-record is generated for each calendar month during which demand occurred based on the month and year indicated in the Julian date of the requisition document. This date is the date the demand was generated and not necessarily the date the transaction was recorded in the computer records. Each MRF record can contain up to 24 monthly demand sub-records.

The levels program computes and posts to the MRF records an average monthly demand (AMD) obtained by summing the quantity demanded during the selected period and dividing by the number of months in the base period. The base period is the period from which demand data will be taken for computing the average monthly demand. It is

established by the input of beginning and ending dates in the levels program. The selected period is the base period less any months of demand excluded from the computation by shipboard managers. This exclusion of demand may be done for months where abnormal operating conditions prevail such as shipyard periods.

MRF records that have been established for less than six months are defined as having inadequate demand history. If an item having inadequate demand history qualifies as a DBI, an average monthly demand is computed by dividing the recorded demand by six months rather than the number of months in the base. The purpose of this computation is to reduce the distortion in stocking level computation caused by the scarcity of demand data. For items with MRF records established for six months or more, AMD is computing by dividing the recorded demand by the base period. Using this procedure, the computed AMD for an item could vary significantly under certain conditions. For instance, an item that qualified as DBI with inadequate demand history would have an initial AMD computed by dividing recorded demand by a base period of six. After processing of levels in the sixth month after establishment of the record, the computation of AMD for this item would be computed by dividing by the selected base which is typically 24. This could cause a significant change in computed AMD between the fifth and sixth periods after record establishment.

The levels program allows the output of a report which identifies items with an AMD computed using the inadequate demand history procedures. The implications of this procedure for management of demand based stock levels will be discussed in a later chapter.

5. Safety Level

A safety level of stock is computed for demand based items. It is computed as the product of a safety level factor multiplied by average monthly demand. The purpose of the safety level is to act as a buffer to reduce the number of stockouts experienced on an item.

6. Reorder Point (RP)

RP is the net asset level (on hand plus on order) at or below which a resupply order will be placed. For demand based items, RP is computed as the sum of the safety level plus the product of order and shipping time in months and the average monthly demand. For non-demand based items, it is equal to a percentage of the RO as set by shipboard inventory control managers within a TYCOM directed range. For COMSUBLANT tenders, this range is from 50 to 80 percent of the RO value.

7. Operating Level (OL)

The operating level is a stock computation based on the economic order quantity (EOQ) formula. As such it is the stocking level for demand based items designed to minimize holding and order costs. The OL is computed by

dividing AMD by unit price, taking the square root of that quantity and multiplying it by a operating level multiplier (OLMF) prescribed by the TYCOM. In this computation the multiplier represents a measure of holding cost. The OL is constrained by a maximum and minimum quantity expressed in terms of months of average demand.

8. Requisitioning Objective (RO)

The requisitioning objective (RO) is defined as the maximum net asset level. It will be attained just after an order is placed. For demand based items, it is computed as the sum of the RP and the operating level. For non-demand based items it is equal to the prescribed numeric requirement (e.g., COSAL quantity or load list quantity or the sum of the two).

9. Excess Material

The levels program also identifies stocks on hand and stocks on order which are considered to be in excess of anticipated needs. These stocks are designated as Redestributable Assets On-Board (RAB), and Redestributable Assets On Order (RAO). Levels processing identifies both RAO and RAB (by adjusting RO's for demand based items), as well as identifying RAO and RAB created by other actions such as COSAL or tender load list changes.

B. SHIPBOARD CONTROL OF LEVELS PARAMETERS

Most of the factors involved in the levels computation can by manipulated to some degree by shipboard managers. Others are directed by the Type Commander. Key parameters which are subject to control by shipboard managers include the following.

1. Base Period of Demand

Shipboard inventory control managers input to the levels program the base period of demand to be used in computation of AMD and in the identification of demand based items. The exclusion from consideration of certain month's demand within the base period is also possible at the discretion of the shipboard manager. Exclusion of these demand values may be warranted due to abnormal operating schedules such as shipyard periods, etc. COMSUBLANT guidance on this matter recommends the use of a 24-month base period when possible and directs exclusion of specific months of demand history "considered to be unrealistic" [Ref. 2]. Even after discussions with knowledgeable personnel at COMSUBLANT, Fleet Material Support Office (FMSO), and Navy Management Systems Support Office (NAVMASSO), the justification behind the preference for a 24-month base period is not clearly defined. The implications of using a 24 month base in the levels computation on forecasting of demand will be addressed in a later chapter.

2. Recomputation Test Factor

This factor is used to determine if stock levels for DBI records will be recomputed by the levels program based on the percent difference between the most recently computed AMD and the previous AMD recorded on the MRF. If the change in AMD is less than the set factor, the RO, RP and AMD will remain the same. This factor may be set by shipboard managers in SUBLANT at either 20 percent or 30 percent. The recomputation test is not applied to DBI records assigned allowance type codes 1 (COSAL), 2 (load list), 3 (items with both COSAL and load list), or 5 (Type Commander authorized items). The purpose of excluding these records from the recomputation test could not be discerned from a review of the referenced material and discussion with Type Commander and FMSO personnel.

3. Operating Level Multiplier

This is the factor used in the computation of the operating level described above. A higher factor will result in a higher OL and thus higher ROs for demand based items. This factor may be set at the shipboard level at any value between eight and ten, inclusive. Shipboard managers may set the multiplier to values consistent with local workload considerations. Setting of a higher multiplier will result in less frequent but higher quantity reorders.

4. Maximum and Minimum OL Constraints

These parameters bound the computed OL by setting maximum and minimum values in terms of months of average monthly demand. The purpose of these constraints is to restrict the effects of the Operating Level Multiplier and regulate the difference between RO and RP. This is necessary to prevent understocking of large unit price items and overstocking of small unitt price items. Shipboard managers may set the minimum constraint between 2.5 and three months of AMD and the maximum between six and nine months of AMD.

5. Percent of RO

This factor is used to compute the reorder point of non-demand based items at a percentage of their RO. A lower percentage will cause less frequent reorders of these items but will result in more stockouts. This parameter may be varied at the ship's discretion between 50 percent and 80 percent.

C. TYPE COMMANDER DIRECTED LEVELS PARAMETERS

Several inputs to the levels program computations are directed by the Type Commander. Definition of these factors and the current COMSUBLANT values are listed below.

1. Order and Shipping Time Factor

This factor is multiplied by AMD to compute part of the RP stock level. The factor is stated in terms of months

of average monthly demand. For tenders based in the continental United States (CONUS) this factor is set at one. Deployed tenders use a factor of two.

2. Safety Level Factor

This factor is used in the computation of the safety level for demand based items discussed above. It is set at two, representing two months of AMD.

3. Economic Retention Dollar Value

This value is used to determine if material identified as excess based on range and depth criteria qualifies for retention based on extended dollar value (unit price x quantity on hand). This parameter is set at $100. Material on hand in excess of RO with an extended dollar value less than or equal to this parameter is retained as authorized stock based on economic retention.

D. WORKLOAD ISSUES OF LEVELS PROCESSING

The output from processing the levels program initiates a series of actions by shipboard inventory managers. Some of these actions are specifically required by TYCOM instruction, others are desirable from the standpoint of prudent management practices. The most significant workload issues are summarized below. The reference for required and recommended actions cited is The Stock Control Officers Guide [Ref. 5], and the Tender Supply Management Instruction [Ref. 2].

1. Management Review of Changes

Several reports are generated by the levels program that identify changes in the tender load. These reports are in summary form as well as more detailed listings of changes to categories of special interest. Review of the reports by supervisory personnel and annotation of action taken is required by Reference 2. Conditions identified in the reports which may require corrective action include:

- Significant variances in stock levels indicating incorrect or inappropriate input of levels parameters.
- Undesirable or inappropriate changes to stock levels caused by insufficient demand history or erroneous input of demand data.
- Errors in MRF record such as unit price of zero assigned to material that is not free issue, or that have a computed AMD so large it exceeds the record field size.
- Stock items now considered excess due to an adjustment in RO based on demand.

2. Physical Movement of Stock

COMSUBLANT prescribes standards for acceptable levels of Redestributable Assets on Board (RAB) at five percent of the dollar value of shipboard authorized stock allowances. Since the levels program can create RAB through adjustment of ROs, any action to off-load items reported as excess in levels output reports are a major concern of shipboard managers. After processing of the levels program, inventory control managers use another SUADPS report known as the SAMMA/SAL to further identify and stratify RAB items

based on dollar values. Once material is identified, turn in documents are generated, material is pulled from stock, packaged as necessary, off loaded and turned in to supply activities ashore. The level of effort involved in these operations will vary based on specific tender hull, site layout and local procedures. The movement of stocks off the ship based on changing ROs represents a significant portion of the routine workload for storage personnel.

3. Processing of Stock Reorders

Regular reorders of stock material is a routine function of inventory control personnel. COMSUBLANT requires at minimum a regular stock reorder review every ten days and three reorder reviews per month of material coded with reorder restriction codes (typically material requiring special handling or stowage). Processing of these orders involves action by inventory control, storage and automated data processing (ADP) personnel. Of these reorders, the one immediately following levels processing is of particular interest to managers since it reflects updated stock action points and additions to stock range. While the frequency of stock reorder reviews is not directly tied to levels processing, the scheduling and nature of this significant reorder is directly affected by the levels run.

4. Cancellation of Excess Stocks Due

The COMSUBLANT standard for Redestributable Assets on Order (RAO) is two percent or less of the money value of

a ship's authorized stock levels. After processing of levels, the SAMMA/SAL report is used to identify items with excess stock due. Although SUADPS includes a program to assist inventory control personnel in this matter, manual intervention to determine current status if often required. Aggressive pursuit of excess stocks due is necessary to prevent them from becoming excess stock on hand.

E. EFFECTIVENESS ISSUES OF LEVELS PROCESSING

Current COMSUBLANT supply effectiveness standards for submarine tenders are summarized below:

	SSBN tenders	SSN tenders
Gross effectiveness	85%	75%
Net effectiveness	90%	90%

Net effectiveness is defined as the percent of demands (requisitions) for carried items filled from on-board stocks. Gross effectiveness is the percent of all demands filled from on-board stock. Partial filling of a requisition counts as a filled demand for effectiveness reporting. Adjusting requisitioning objectives and reorder points as demand changes is needed to achieve TYCOM effectiveness goals. COMSUBLANT guidance advises that monthly levels processing is necessary to "retain realistic ROs and RPs which reflect the current demand experience" [Ref. 2].

The frequency of levels processing for demand based stocked items affects the workload actions and supply effectiveness issues described above and is the focus of this study.

F. REVIEW OF PREVIOUS STUDIES

The Fleet Material Support Office (FMSO) has conducted several studies related to the management of tender inventories. Two studies of particular relevance to this thesis are FMSO report 112 [Ref. 6], and FMSO report 153 [Ref. 7]. The key findings of these studies are summarized below.

1. FMSO Report 112

The purpose of this study, published in July 1974, was to measure the impact of varying various SUADPS parameters on workload (measured by frequency of resupply orders), requisition effectiveness, and average inventory investment. The study was conducted using a computer simulation model developed by FMSO. Data for the simulation was taken from the historical demand records of USS SPERRY (AS 12), USS DIXON (AS 37) and USS PROTEUS (AS 19). Two years of demand data were used for the SPERRY and DIXON simulations, while only six months of data were available for the PROTEUS simulation. At the time of the study, SPERRY and DIXON were servicing attack submarines; while PROTEUS tended Fleet Ballistic Missile submarines. The

simulation was tailored for each ship to reflect its mission and site location.

The simulation measured the impact of varying one of the levels parameters studied while holding the others constant at COMSUBPAC benchmark values. The parameters studied and their benchmark values are listed below:

- DBI (POS) Qualification Criteria: Two requisitions received in the most recent six months.
- DBI Retention Criteria: One requisition received in the most recent six months.
- Operating Level Multiplier (OLM): Ten months.
- Maximum Operating Level (MAX): Twelve months of Average Monthly Demand (AMD).
- Minimum Operating Level (MIN): One half month of AMD.
- Safety Level (SL): Three months of AMD.
- Percentage of RO set as RP (for non DBI): 67 percent for the SPERRY and DIXON, 75 percent for the PROTEUS.

The effect of varying the parameters was judged to be significant if:

- Frequency of orders varied by five percent or more from that for the benchmark value.
- Requisition effectiveness varied by more than two percent from that for the benchmark value.
- Average inventory investment varied by five percent or more from that for the benchmark value.

The effect was judged to be very significant if the indicator in question varied more than 20 percent. The results of the study are summarized in Table I reproduced from Reference 6.

TABLE I

IMPACT OF PARAMETER CHANGES ON KEY INDICATORS

INDICATORS

PARAMETER	WORKLOAD	EFFECTIVENESS	INVENTORY INVESTMENT
DBI Criteria	NS	S	VS
OLM	S	NS	S
MAX	NS (unless < 5)	NS	NS
MIN	NS	NS	NS (unless > 1.75)
SL	NS	S	VS
% of RO	S	NS	S

S = significant NS = not significant VS = very significant

2. FMSO Report 153

The purpose of this 1983 study was to evaluate alternative Demand Based Item criteria and Selected Item Management (SIM) criteria relative to the current COMSUBLANT/COMSUBPAC criteria for automated (tenders) and non-automated (submarines) ships. SIM is the inventory control technique used on non-automated ships to focus management attention on those items experiencing the majority of on-board demands. It is similar in concept to the DBI stocking procedures used on SUADPS ships. Using a computer simulation model and historical demand data, the alternative criteria were evaluated in terms of:

- Gross requisition effectiveness.
- Dollar value investment in on hand stock.
- Workload measured as the number of resupply orders.
- Volatility of the DBI stock battery measured in terms of size and the rate of adds/deletes.

At the time of the study the DBI criteria for automated ships was (and still is) two requisitions in six months to qualify and two in 12 months to retain. The standard for non-automated ships was two requisitions in six months to qualify and one in six months to retain. These criteria were evaluated against 11 others in the simulation. Included in the alternative criteria evaluated was the one recommended by the General Accounting Office (GAO) that bases qualification on the number of months with occurrence of demand instead of the number of requisitions. The alternative policies and their SIM/DBI criteria are listed in Table II below.

The simulations were run for five ships: USS SIMON LAKE (AS 33), USS FULTON (AS 11), USS DIXON (AS 37), USS LAPON (SSN 661) and USS DRUM (SSN 677). Historical demand for the tenders were obtained from the MRF records of each ship. Demand data for the submarines were obtained from the Navy Maintenance and Material Management (3M) data bank.

In the evaluation of the alternative criteria, the study assumed that the best criteria should reduce dollar investment and volatility with no decrease in effectiveness

TABLE II

ALTERNATIVE POLICIES EVALUATED IN FMSO REPORT 153

POLICY	QUALIFICATION CRITERIA	RETENTION CRITERIA
Benchmark	2 requisitions in last 6 months	1 requisition in last 6 months
1 (Navy Proposal)	2 requisitions in last 6 months	2 requisitions in last 12 months
2	2 requisitions in last 12 months	1 requisition in last 12 months
3	2 months with demand in last 12 months	1 month with demand in last 12 months
4	2 months with demand in last 6 months	1 month with demand in last 6 months
5	2 requisitions in last 6 months	1 requisition in last 12 months
6	3 requisitions in last 6 months for allowance items; 2 requisitions in last 6 months for nonallowance items	1 requisition in last 6 months for both allowance and nonallowance items
7 (GAO Proposal)	2 months with demand in last 6 months	2 months with demand in last 12 months
8	2 months with demand in last 6 months	1 month with demand in last 12 months
9	4 requisitions in last 12 months	4 requisitions in last 12 months
10	4 requisitions in last 12 months	2 requisitions in last 12 months
11	4 months with demand in last 12 months	4 months with demand in last 12 months
12	4 months with demand in last 12 months	2 months with demand in last 12 months

relative to the benchmark criteria. Table III (reproduced from Reference 7) summarizes the effects of the evaluated policies in terms of the following statistics:

- Gross Requisition Effectiveness. This is computed by dividing the number of requisitions totally satisfied plus the number of requisitions partially satisfied during the last year of the simulation by the number of requisitions placed during the same year of the simulation.

- Dollar Value of On-hand Plus Due in Stock. This figure is a measure of inventory investment and is computed as the dollar value of on-hand plus on order stock at the end of the simulation for all items that experienced demand during the simulation period.

- Volatility. The volatility statistic consists of three elements: the number of items qualifying as SIM/DBI during the last year of the simulation (adds), the number of items returning to a non SIM/DBI status during the same period of the simulation (deletes), and the total number of DBI items at the end of the simulation.

The study concluded that policies 4, 6, 7, 8, 9, 10, 11, and 12 permitted an unacceptable degradation in effectiveness and were not suitable for further consideration. The remaining policies were considered further and, based on workload and investment considerations, the SIM/DBI criteria of two requisitions in six months to qualify and two requisitions in 12 months to retain was recommended for adoption by submarines and submarine tenders.

TABLE IV

SIM/DBI SUMMARY CHART ACROSS ALL SHIPS (NSA ITEMS ONLY)

Criteria	Policy	Gross Requ. Eff.	OH + DI (Cost)	Volatility
2/6-1/6 (Freq)	Benchmark	With the exception of the SSNs, highest effectiveness	Generally has highest investment	SIM/DBI battery average; # adds & deletes generally the highest.
2/6-2/12 (Freq)	1 (Navy Proposal)	Same as benchmark	0-1% increase from benchmark	# of SIM/DBI items always higher than benchmark; # of adds & deletes lower than benchmark.
2/12-1/12 (Freq)	2	0-1% increase from benchmark.	3-7% increase from benchmark	# of SIM/DBI items always higher than benchmark; # of adds higher for SSNs but lower than benchmark for ASs and # of deletes always lower than benchmark.
2/12-1/12 (Mon.)	3	Same as benchmark	1-3% increase from benchmark; except for SSN 677 - 5% decrease	# of SIM/DBI items always higher than benchmark; # of adds & deletes always lower than benchmark.
2/6-1/6 (Mon.)	4	0-1% decrease from benchmark	3-12% decrease from benchmark	# of SIM/DBI items always lower than benchmark; # of adds & deletes lower than benchmark.
2/6-1/12 (Freq)	5	Same as benchmark	0-2% increase from benchmark	# of SIM/DBI items always higher than benchmark; # adds & deletes lower than benchmark.
3/6 2/6-1/6 (Freq)	6	0-1% decrease from benchmark	3-6% decrease from benchmark	# of SIM/DBI items always lower than benchmark; # adds & deletes lower than benchmark.
2/6-2/12 (Mon.)	7 (GAO Proposal)	0-1% decrease from benchmark	2-12% decrease from benchmark	# of SIM/DBI items higher than benchmark, except for AS(FBM)33; # adds & deletes lower than benchmark.
2/6-1/12 (Mon.)	8	0-1% decrease from benchmark	2-12% decrease from benchmark	# SIM/DBI items always higher than benchmark; # adds & deletes always lower than benchmark.
4/12-4/12 (Freq)	9	2-4% decrease from benchmark	13-37% decrease from benchmark	# SIM/DBI items significantly lower than benchmark; # adds & deletes significantly lower than benchmark.
4/12-2/12 (Freq)	10	1-4% decrease from benchmark	13-37% decrease from benchmark	# SIM/DBI items significantly lower than benchmark; # adds & deletes significantly lower than benchmark.
4/12-4/12 (Mon.)	11	2-5% decrease from benchmark	19-42% decrease from benchmark	# SIM/DBI items significantly lower than benchmark; # adds & deletes significantly lower than benchmark.
4/12-2/12 (Mon.)	12	2-5% decrease from benchmark	18-42% decrease from benchmark	# SIM/DBI items significantly lower than benchmark; # adds & deletes significantly lower than benchmark.

III. ANALYSIS METHODOLOGY

A. OBJECTIVES OF THE ANALYSIS METHODOLOGY

As presented in Chapter I, the primary questions of this thesis concern the effects on supply effectiveness and stock churn (i.e., the number of additions and deletions to the range of demand based stock items) of less frequent processing of the levels program aboard submarine tenders utilizing the SUADPS inventory control system. The objectives of the analysis methods described in this chapter were to measure these effects by simulating the actions of the levels processing program for various processing frequencies using actual demand data from an operating submarine tender.

This chapter describes in detail the actions of the levels program that directly impact supply effectiveness and stock churn. It then describes the source of data and design of the method used to simulate these actions. Finally, the limitations and assumptions of the simulation method are discussed.

B. EFFECTS OF LEVELS PROCESSING FREQUENCY ON SUPPLY EFFECTIVENESS

Frequency of levels processing can affect supply effectiveness in two ways. First, failure to run the levels program in a given period may result in an item that would

qualify for stocking based on DBI criteria being ignored. As a result, a requisitioning objective for this item will not be computed and it will not be ordered for stock. If demand occurs for this item again after sufficient time has elapsed for order and shipping of a stock order then a stock-out will occur which would have been avoided if levels had been run during the initial period. This event can be described as a failure to adjust the range of demand based stock items.

A second way the levels processing frequency can affect supply effectiveness is by failure to adjust the requisitioning objective (RO) and reorder point (RP) of a carried item based on an increase in demand. Failure to run levels during a period when an increase in the quantity demanded occurs will result in preventing the recomputation of ROs and RPs that would otherwise take place due to such a change in demand. If this increasing demand trend continues in later periods a stockout may occur because the computed RO and RP have lagged behind the change in demand. This event can be described as a failure to adjust the depth of demand based stock items.

Determining the extent to which the occurrence of these two events is affected by less frequent processing of the levels program is the first major objective of the analysis methods.

C. EFFECTS OF LEVELS PROCESSING FREQUENCY ON STOCK CHURN

Less frequent levels processing can affect stock churn by reducing the number of times that an item's demand history is reviewed to determine if it meets criteria for demand based stocking. Each time this review is executed as part of the levels program, items that are not stocked but whose demand history reflects two or more requisitions in the past six months are added to the range of stock items carried based on demand. Conversely, items that are stocked but whose demand history reflects less than two requisitions in the last 12 months are deleted from the demand based stock range.

Measuring the extent to which the frequency of these addition and deletion events are affected by less frequent review of demand history through the levels program is the second major objective of the analysis methods employed in this study.

D. SOURCES OF DATA

In order to simulate the events of interest described above, actual transaction data from an operating submarine tender was desired that could be used to simulate the actions of requisitioning, issue, order and receipt over time. In addition detailed Master Record File (MRF) data for each item with demand history was desired so that the effects of non-demand based factors such as tender load list

allowances, special material categories (e.g., repairable items) could be reproduced in the simulation. These data could be used to simulate realistic inventory conditions associated with different levels processing frequencies.

As noted in Chapter I, time constraints and limitations on data processing resources prevented the collection and use of the detailed data described above. With the assistance of COMSUBLANT staff, detailed transaction data representing one month's business aboard USS SIMON LAKE (AS 33) in the form of a cumulative Transaction Ledger (CTL) magnetic tape were obtained and analyzed. Unfortunately, since the CTL contains a record of all transactions affecting the MRF including many not of interest to this study (such as stowage location changes and local management code assignments), collection and processing of demand data for any significant time period (two years or more) in this format would involve the use of computer hardware and personnel resources that were not within the time and resource constraints of this study. For example, collection and analysis of 24 months of demand history in this format would involve the production, shipping, and processing of 12 magnetic tapes containing approximately 1,200,000 transactions, of which only about 20 percent would be of interest to this study.

The primary data used in this analysis and simulation were collected from the demand sub-records contained in the

MRF records of the USS FRANK CABLE (AS-40). FRANK CABLE is a submarine tender servicing attack (SSN) submarines. These demand sub-records covered the period from September 1988 to August 1990 and included the demand history for 25,425 line items. The data were produced in magnetic tape format by processing of a file analyzer program (FIANA) by ADP personnel aboard the ship.

Several characteristics of the data were key factors in the limitations and design of the analysis methods employed and are summarized below.

Demand sub-records are generated for each calendar month during which demand occurred based on the Julian date of the requisition document. A sub-record includes a summary count of quantity and frequency of demands recorded against an item during that month. The monthly summary format of the data did not allow the simulation of individual demand transactions and their effect on stock balances, reorders, etc. As a result direct calculation of supply effectiveness statistics in the manner described in Chapter II could not be accomplished.

The data also did not contain unit price information for each stock record. Since unit price is used in the computation of the Operating Level by the levels program, the lack of this information precluded a complete levels simulation for the entire range of stock records represented in the MRF sub-records.

The data also did not contain information such as cognizance symbol or special material identification codes that could be used to segregate items based on type of material or special controls (e.g., repairable items). In practice, the levels program is not run against some types of items (e.g., repairable items on SSN tenders). The effects of this exclusion could not be duplicated in the simulation.

Finally, the data did not contain stock allowance information such as COSAL or load list quantities for individual stock records. As a result, the focus of the simulation and analysis was on the effects of demand on stock levels and ignored the effects of other allowances. In practice, these other stock allowances are accounted for in the levels program as discussed in Chapter II.

In order to assist in interpretation of the simulation results, a summary by allowance type (AT) of the stock load aboard FRANK CABLE as of August 1990 was obtained from shipboard SUADPS reports. This summary provides a snapshot view of stock allowances as of the last month of the time period from which the simulation data was drawn. The AT code summary was used in the analysis of the simulation results to provide some accounting of the effect of other stock allowances on levels processing.

The data did not contain a record of on-hand balances over time for each stocked item represented in the MRF

sub-records. This prevented the initialization of the simulation with beginning balances. This limitation directly affected the design of the effectiveness and churn indicators used in the simulation that are described in detail below.

E. STRUCTURE OF THE ANALYSIS METHODS

The methodology employed in this study was designed to address the two key questions of the thesis given the limitations of the data available. As discussed above, the primary questions involve the effect on requisition effectiveness and stock churn as the frequency of levels processing is reduced from the current COMSUBLANT monthly requirement. The methods of analysis used to address these two major issues are described below.

F. RANGE SIMULATION

A simulation model was used to measure the change in the frequency of the range addition failure event as the levels processing frequency was varied from monthly to bi-monthly and to quarterly. The simulation model did not employ the "Monte Carlo" technique. The historical demand data were not fitted to a probability distribution for the purposes of generating random demand values. Rather, the historical data was used to recreate the actual observed demand within the simulation. This simulation model, referred to hence-forth as the range simulation, was designed to replicate the

levels demand history review process and associated demand based stock range actions described above.

In addition, the range simulation allowed the measurement of the stock churn in terms of additions and deletions to the stock range based on demand. The assumptions and procedures of the range simulation are described below.

1. Assumptions of the Range Simulation

The following assumptions were made in the design of the range simulation.

At the start of the simulation, nothing is carried in the stock load. The stock range adjustment actions of the simulation are based only on the review of the demand history contained in the data. This assumption is necessary due to the lack of stock allowance data and previous demand history.

The simulation began with processing of the levels program using demand history from September 1988 (designated month one). Processing of the levels program in subsequent months (designated months two through 24) used demand history for all months up to and including the month of the levels run.

The program is assumed to be run at the end of the month in which it is scheduled and adjustment of demand based stock ranges based on the levels demand review are assumed to take place at the beginning of the next month.

The criteria for designation of Demand Based Items (DBI) used in the simulation are the current COMSUBLANT criteria of two requisitions in the last six months to qualify as DBI and twp requisitions in 12 months to retain DBI status.

Items qualifying as DBI during the simulation are assumed to be ordered for stock at the beginning of the month after the month in which they qualified. This stock is assumed to be received and available for issue at the beginning of the month after the month of order. For example, an item that qualified as DBI during the levels demand review for month one was assumed to have on-hand stocks available for issue at the beginning of month three.

Once qualified for DBI stock, items are assumed to maintain on hand stock balances sufficient to satisfy all issues. The impact of the depth of stock levels on effectiveness is ignored in the range simulation since computation of operating levels was not possible due to the lack of unit price and allowance data.

Items that have qualified for DBI stock and subsequently fail to meet DBI retention criteria during the study are assumed to be off-loaded and unavailable for issue. This off-load is assumed to take place at the end of the month following the levels review that caused the loss of DBI status. For example, an item that had qualified for DBI stock in month one but failed to meet DBI retention

criteria during the levels review in month 13 was assumed to be off-loaded and unavailable for issue at the start of month 15. Note that economic retention criteria is ignored in this assumption due to the lack of unit price data.

2. Simulation Events and Indicators

Within the range simulation certain events were designated as effectiveness or stock churn indicators for the influence of the levels processing frequency on the stock range addition and churn events described above.

a. Stockout Month

This event occurs in the simulation when there is recorded demand during a month having no on-hand stocks available for issue. The observed frequency of this event was used to measure the relationship between levels processing frequency and supply effectiveness degradation due to delays in adjusting stock range when demand is changing. Note that since all items are assumed to be not carried at the start of the simulation, all items will experience at least one stockout month during the simulation as a result of the first demand review occurring in month one.

b. Add

This event occurs in the simulation when an item is selected for stock based on the DBI criterion during a levels demand review. The frequency of this event during the simulation was used as one indicator of the amount of

churn in the demand based stock items as a function of levels processing frequency.

c. Delete

This event occurs in the simulation when an item that had previously qualified for stock based on the DBI criteria fails to meet DBI retention criteria during a levels demand review. The frequency of this event during the simulation was used as the second indicator of the amount of churn in the demand based stock items as a function of levels processing.

3. Simulation Procedures

The range simulation was conducted in the following sequence:

- The simulation was run against the demand data in aggregate in three iterations. The first iteration set the levels processing frequency at monthly. In this iteration the demand review described above took place in every month from one to 24. The second iteration set the levels processing at bi-monthly causing the demand review to take place in alternate months beginning with month one and ending in month 23 (i.e., months one, three, five, etc.). In the third iteration the levels processing frequency was set at quarterly, causing the demand review to occur in months one, four, seven, etc., up to month 22.

- The simulation was run for each of 24 groups of line items; each group corresponding to a number of months with recorded demand. For example, all line items having demand occurring in only five months of the 24 months recorded constituted one group. These simulations were also run in three iterations for each demand group, one each for the levels processing frequencies.

- At the end of each simulation run, the results were recorded in terms of the number of observations of the indicator events; the number of adds, deletes and

stockout months. The add and delete values were recorded both as a total and as a percent of line items (stock records). The stockout month values were recorded as totals and as a percent of months with demand.

G. DEPTH SIMULATION

To measure the influence of the levels processing frequency on the second supply effectiveness event of interest; depth adjustment failure, the change in the computed RO and RP in response to observed demand must be measured. Since the lack of unit price data in the MRF sub-records precluded a complete examination of all item sub-records, a levels simulation was conducted on a small group of selected items, for which unit price information was obtained manually from Management List Navy (MLN) microfiche listings. This simulation, referred to henceforth as the depth simulation, was designed to simulate the adjustment of stock levels for demand based items by the levels program. The simulation measured the change in the frequency of occurrence of the depth adjustment failure event described earlier in this chapter as the levels processing frequency was varied from monthly to bi-monthly and to quarterly. The assumptions and procedures of the depth simulation are described below.

1. Assumptions of the Depth Simulation

The following assumptions were made in the design of the depth simulation:

- At the start of the simulation, all items were considered to be not carried. As in the range simulation, only demand history is considered in the simulation; the effects of other stocking considerations are ignored.

- As in the range simulation, the depth simulation begins with levels processing using demand data from September 1988 (month one). Subsequent levels processing uses demand data up to and including the month in which it is run.

- Adjustments to stock depth based on levels processing are assumed to occur at the beginning of the month following the month in which the levels program is run.

- Items qualifying for stock as DBI during the simulation are assumed to be ordered for stock at the beginning of the month after the month of levels processing in which they qualified. These stocks are assumed to be received and available for issue at the beginning of the month after the month of order. For example, an item that qualified for stock based on demand as a result of levels processing in month one was assumed to have on-hand stocks available for issue at the beginning of month three.

- Stock resupply orders are assumed to be placed at the beginning of each month if necessary and are received at the beginning of the next month. Stock orders are triggered when the on-hand balance at the beginning of the month is less than the computed RP. The order quantity is computed by subtracting the sum of on-hand stock plus stock due in from RO.

- Stocks that qualify as DBI during the simulation and subsequently fail to retain DBI status are assumed to be off-loaded and unavailable for issue if they do not meet economic retention criteria. If items are off-loaded, this action is assumed to take place at the end of the month following the month of levels processing which caused the loss of DBI status.

- The levels program parameters used in the computation of stock levels during the depth simulation that are subject to discretion of shipboard managers were selected from within the constraints of Reference 2. A summary of the selected parameters and the COMSUBLANT constraints is shown in Table IV below.

TABLE III

SELECTION OF PARAMETERS USED IN DEPTH SIMULATION

PARAMETER	PERMISSIBLE RANGE	SIMULATION VALUE
Recomputation Test Factor	20 to 30%	20%
Operating Level Multiplier	8 to 10	9
Maximum Months in Operating Level	6 to 9	7
Minimum Months in Operating Level	2.5 to 3	2.8

2. Depth Simulation Events and Effectiveness Indicators

Within the depth simulation, certain events were designated as effectiveness indicators for the influence of the levels processing frequency on stock depth computations.

a. Stockout Month

This event occurs in the simulation when the total quantity demanded during a month exceeds the quantity on hand at the beginning of that month. The observed frequency of this event as a result of the simulation was used to measure the relationship between levels processing frequency and the degradation of supply effectiveness caused by a failure to adjust stock depth based on a change in demand.

b. Backorders

This event occurs as a result of the stockout month event and is measured as the difference in any

stockout month between the quantity demanded and the quantity on hand at the beginning of the month. The total quantity of backorders was used as an indicator of the degree to which computed stock levels were sufficient to meet demand for a given frequency of levels processing.

3. Depth Simulation Procedures

The depth simulation was run using demand history for five items selected from the demand sub-record data. Items were selected for the depth simulation based on their representation of the various demand patterns found in the data as a whole. The items were selected from the months of demand categories of two, three, six, 12 and 20. Items were selected that exhibited sufficient frequency of demand to qualify as DBI and displayed enough variation in quantity demanded to cause some recomputaton of AMD, RO and RP. This was done to allow the observation of the effects of less frequent levels processing on the recomputation process.

The depth simulation was run against each item in three iterations; one each for monthly, bi-monthly and quarterly levels processing. After each simulation run, the values of the total stockout months and number of backorders were recorded.

The depth simulation results were also used to examine certain levels program procedures involved in the computation of RO and RP. These procedures, discussed in detail in Chapter II, were:

- The use of a 24-month base in the computation of AMD.
- The use of a 6-month base in the computation of AMD for items with inadequate demand history.

IV. RESULTS OF THE ANALYSES

A. RESULTS OF RANGE SIMULATION

1. Aggregate Results

The results of the range simulation involving all demand sub-records in total are summarized in Tables V and VI. Table V displays the values of the stockout month indicator described in Chapter III as a result of running the range simulation for each of the three levels processing frequencies (monthly, bi-monthly and quarterly). The values are displayed as a total number and as a percent of the total demand months present in the demand sub-records.

TABLE V

RANGE SIMULATION RESULTS:
STOCKOUT MONTHS FOR THE THREE FREQUENCIES OF LEVELS PROCESSING:
TOTAL VALUES AND AS PERCENT OF MONTHS OF DEMAND

LEVELS PROCESSING FREQUENCY	STOCKOUT MONTHS	MONTHS OF DEMAND	PERCENT
MONTHLY	41,009	75,137	54.58
BI-MONTHLY	41,961	75,137	55.85
QUARTERLY	43,290	75,137	57.61

A demand month represents the occurrence of at least one requisition against a stock record in a given month. Total demand months are equal to the total number of demand

TABLE VI

RANGE SIMULATION RESULTS:
ADDS AND DELETES FOR THE THREE FREQUENCIES OF LEVELS PROCESSING: TOTAL VALUES AND AS PERCENT OF LINE ITEMS

LEVELS PROCESSING FREQUENCY	NUMBER ADDS	PERCENT OF LINE ITEMS	NUMBER DELETES	PERCENT OF LINE ITEMS
MONTHLY	14,555	57.25	5791	22.78
BI-MONTHLY	14,202	55.86	5440	21.40
QUARTERLY	13,434	52.84	4554	17.91
TOTAL LINE ITEMS	25,425			

sub-records contained in the data. The demand sub-records used in the simulation contained 75,137 months of demand history for 25,425 stock records. The value of stockout months as a percent of total demand months represents that fraction of demand months that occurred in the simulation against a record with no on-hand quantity available for issue. The increase in this percentage as a function of varying levels processing frequency from monthly to bi-monthly and to quarterly is a measure of the decrease in supply effectiveness caused by less frequent processing of the levels program.

Table VI displays the value of the add and delete indicators described in Chapter III as a result of running the range simulation for each of the levels processing frequencies. The value is expressed both as a total number and as a percent of the line items (stock records)

represented in the demand data. The decrease in value of the add and delete indicators are a measurement of the reduced stock churn for demand based items as levels processing frequency is reduced.

2. Results by Months of Demand

In the second stage of the range simulation, the demand sub-records were segregated into categories corresponding to the number of months out of the 24 months of data with recorded demand and the simulation was run for each of these categories separately. The purpose of this second stage simulation was to determine the effect of varying levels frequency on items with different demand history patterns (e.g., slow moving items versus fast moving items).

The results of the second stage range simulation are displayed in Tables VII-X. Table VII lists the total number of stockout months for each demand category for each levels processing frequency. Table VIII displays the same information expressed in terms of stockout months as a percentage of total demand months in each category. The percentage frequency represents the fraction of demand months within each category that resulted in a stockout month during the simulation. The change in this percentage represents the difference in the fraction of demand months that were stockout months in the simulation as levels processing frequency was varied from monthly to bi-monthly

TABLE VII

RANGE SIMULATION RESULTS: NUMBER OF STOCKOUT MONTHS FOR EACH MONTH OF DEMAND CATEGORY

MONTHS OF DEMAND CATEGORY	NUMBER OF ITEMS	TOTAL MONTHS DEMAND	NUMBER OF STOCKOUT MONTHS FOR GIVEN LEVELS FREQUENCY MONTHLY	BI-MONTHLY	QUARTERLY
1	12220	12220	12220	12220	12220
2	4767	9534	9218	9223	9247
3	2501	7503	5876	5938	6052
4	1458	5832	3560	3673	3794
5	987	4935	2404	2510	2589
6	713	4278	1657	1747	1894
7	531	3717	1189	1265	1371
8	423	3384	923	1007	1109
9	312	2808	675	741	832
10	258	2580	552	602	691
11	225	2475	485	533	597
12	197	2364	439	474	565
13	172	2236	372	419	489
14	131	1834	286	322	368
15	115	1725	253	276	322
16	92	1472	201	225	255
17	60	1020	133	150	177
18	84	1512	180	207	239
19	58	1102	129	140	156
20	41	820	90	110	130
21	26	546	53	58	65
22	19	418	42	47	52
23	18	414	38	40	42
24	17	408	34	34	34
TOTALS	25425	75137	41009	41961	43290

TABLE VIII

RANGE SIMULATION RESULTS:
STOCKOUT MONTHS AS PERCENT OF MONTHS DEMAND FOR GIVEN LEVELS
PROCESSING FREQUENCY AND PERCENT CHANGE FROM
MONTHLY RESULT

MONTHS OF DEMAND CATEGORY	MONTHLY LEVELS	BI-MONTHLY LEVELS	PERCENT CHANGE	QUARTERLY LEVELS	PERCENT CHANGE
1	100.00%	100.00%	0.00%	100.00%	0.00%
2	96.69%	96.74%	0.05%	96.99%	0.30%
3	78.32%	79.14%	0.82%	80.66%	2.34%
4	61.04%	62.98%	1.94%	65.05%	4.01%
5	48.71%	50.86%	2.15%	52.46%	3.75%
6	38.73%	40.84%	2.11%	44.27%	5.54%
7	31.99%	34.03%	2.04%	36.88%	4.89%
8	27.28%	29.76%	2.48%	32.77%	5.49%
9	24.04%	26.39%	2.35%	29.63%	5.59%
10	21.40%	23.33%	1.93%	26.78%	5.38%
11	19.60%	21.54%	1.94%	24.12%	4.52%
12	18.57%	20.05%	1.48%	23.90%	5.33%
13	16.64%	18.74%	2.10%	21.87%	5.23%
14	15.59%	17.56%	1.97%	20.07%	4.48%
15	14.67%	16.00%	1.33%	18.67%	4.00%
16	13.65%	15.29%	1.64%	17.32%	3.67%
17	13.04%	14.71%	1.67%	17.35%	4.31%
18	11.90%	13.69%	1.79%	15.81%	3.91%
19	11.71%	12.70%	0.99%	14.16%	2.45%
20	10.98%	13.41%	2.43%	15.85%	4.87%
21	9.71%	10.62%	0.91%	11.90%	2.19%
22	10.05%	11.24%	1.19%	12.44%	2.39%
23	9.18%	9.66%	0.48%	10.14%	0.96%
24	8.33%	8.33%	0.00%	8.33%	0.00%

and to quarterly. For example, as shown in Table VII, there were a total of 9534 months of demand recorded for the 4767 line items that had two months with demand out of the 24 month period. During the simulation using a monthly levels processing frequency, 9218 of these months of demand occurred with no on-hand stocks available for issue. In this case, the percentage of demand months that were stockout months for this category was 96.69 percent (9218 divided by 9534), as shown in Table VIII. The bi-monthly simulation for this category resulted in a stockout month percentage of 96.74. The difference between these two values is shown in Table VIII as 0.05 percent, representing the change in the effectiveness indicator for this demand category caused by reducing the frequency of levels processing from monthly to bi-monthly .

Figure 1 presents a graphical display of the data contained in Table VIII. The horizontal axis represents the months of demand categories. A separate curve is plotted to show stockout months as a percentage of demand months for each levels frequency.

Tables IX and X display the total number of adds and deletes over the 24 months of data within each category of demand as a result of running the simulation for each levels frequency. The data is presented also as a percentage of the line items within each demand category. The percentage

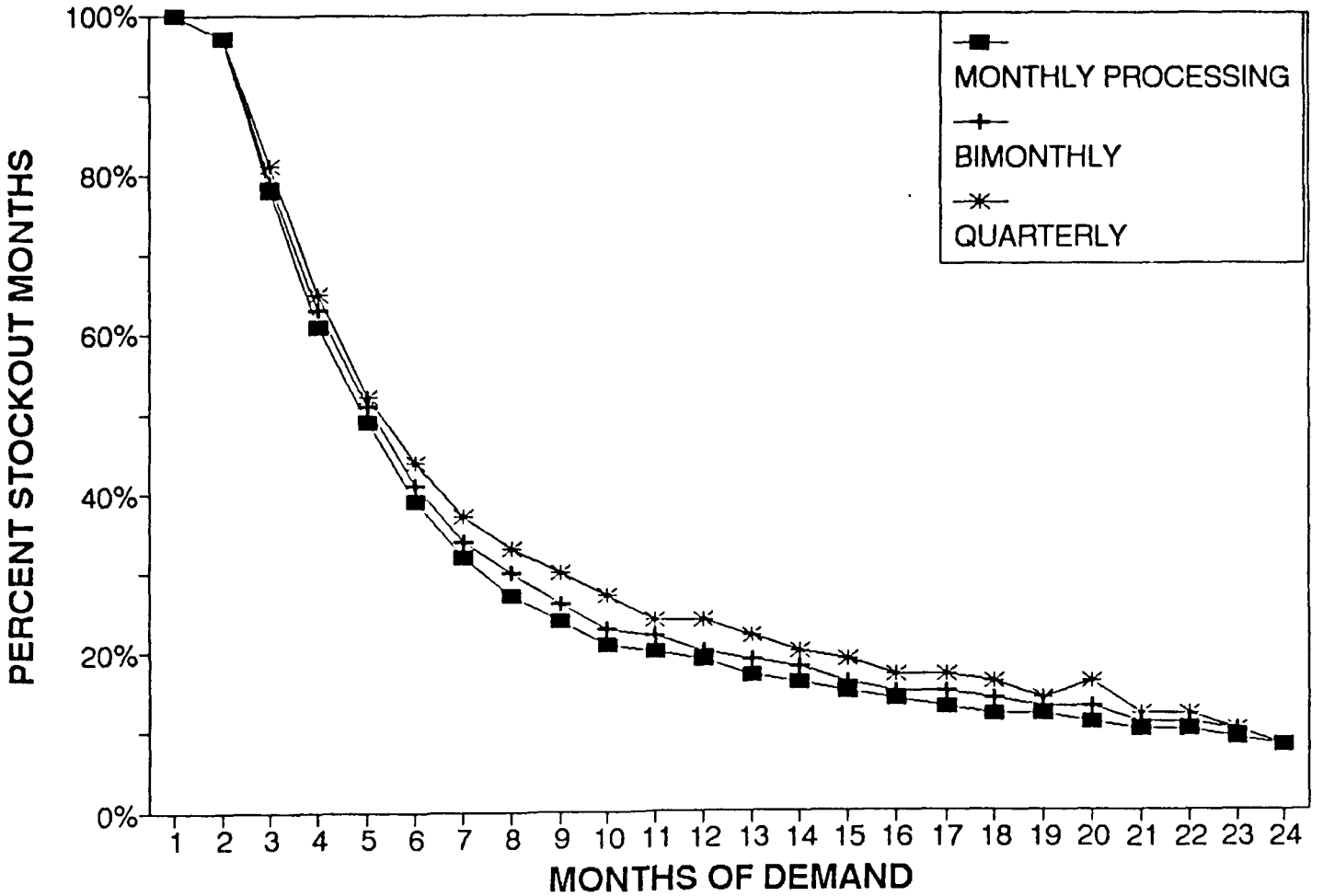

Figure 1. Stockout Months as Percent of Months Demand (Results by Months of Demand Out of 24)

TABLE IX

RANGE SIMULATION RESULTS:
TOTAL NUMBER OF ADDS OVER 24 MONTHS AND AS PERCENT OF LINE ITEMS; BY MONTHS OF DEMAND CATEGORY

MONTHS OF DEMAND CATEGORY	NUMBER OF LINE ITEMS	MONTHLY		BIMONTHLY		QUARTERLY	
		NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
1	12220	1084	8.87%	1084	8.87%	1016	8.31%
2	4767	3822	80.18%	3753	78.73%	3465	72.69%
3	2501	2888	115.47%	2786	111.40%	2592	103.64%
4	1458	1850	126.89%	1772	121.54%	1655	113.51%
5	987	1213	122.90%	1163	117.83%	1103	111.75%
6	713	828	116.13%	798	111.92%	776	108.84%
7	531	582	109.60%	568	106.97%	557	104.90%
8	423	453	107.09%	446	105.44%	439	103.78%
9	312	320	102.56%	318	101.92%	316	101.28%
10	258	258	100.00%	258	100.00%	258	100.00%
11	225	226	100.44%	225	100.00%	226	100.44%
12	197	198	100.51%	198	100.51%	198	100.51%
13	172	172	100.00%	172	100.00%	172	100.00%
14	131	131	100.00%	131	100.00%	131	100.00%
15	115	115	100.00%	115	100.00%	115	100.00%
16	92	92	100.00%	92	100.00%	92	100.00%
17	60	60	100.00%	60	100.00%	60	100.00%
18	84	84	100.00%	84	100.00%	84	100.00%
19	58	58	100.00%	58	100.00%	58	100.00%
20	41	41	100.00%	41	100.00%	41	100.00%
21	26	26	100.00%	26	100.00%	26	100.00%
22	19	19	100.00%	19	100.00%	19	100.00%
23	18	18	100.00%	18	100.00%	18	100.00%
24	17	17	100.00%	17	100.00%	17	100.00%
TOTALS	25425	14555	57.25%	14202	55.86%	13434	52.84%

TABLE X

RANGE SIMULATION RESULTS:
TOTAL NUMBER OF DELETES OVER 24 MONTHS AND AS PERCENT OF LINE ITEMS; RESULTS BY MONTHS OF DEMAND CATEGORY

MONTHS OF DEMAND CATEGORY	NUMBER OF LINE ITEMS	MONTHLY		BI-MONTHLY		QUARTERLY	
		NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
1	12220	508	4.16%	508	4.16%	465	3.81%
2	4767	2192	45.98%	2123	44.54%	1816	38.10%
3	2501	1555	62.18%	1453	58.10%	1195	47.78%
4	1458	823	56.45%	745	51.10%	602	41.29%
5	987	398	40.32%	348	35.26%	270	27.36%
6	713	181	25.39%	151	21.18%	126	17.67%
7	531	76	14.31%	62	11.68%	48	9.04%
8	423	46	10.87%	39	9.22%	26	6.15%
9	312	12	3.85%	10	3.21%	7	2.24%
10	258	3	1.16%	3	1.16%	1	0.39%
11	225	1	0.44%	0	0.00%	1	0.44%
12	197	1	0.51%	1	0.51%	1	0.51%
13	172	0	0.00%	0	0.00%	0	0.00%
14	131	0	0.00%	0	0.00%	0	0.00%
15	115	0	0.00%	0	0.00%	0	0.00%
16	92	0	0.00%	0	0.00%	0	0.00%
17	60	0	0.00%	0	0.00%	0	0.00%
18	84	0	0.00%	0	0.00%	0	0.00%
19	58	0	0.00%	0	0.00%	0	0.00%
20	41	0	0.00%	0	0.00%	0	0.00%
21	26	0	0.00%	0	0.00%	0	0.00%
22	19	0	0.00%	0	0.00%	0	0.00%
23	18	0	0.00%	0	0.00%	0	0.00%
24	17	0	0.00%	0	0.00%	0	0.00%
TOTALS	25425	5796	22.80%	5443	21.41%	4558	17.93%

values over 100 correspond to more than one add for some items during the 24 months.

Figures 2 and 3 display the information contained in Tables IX and X, respectively. Separate curves for each levels frequency are plotted and represent the number of adds and deletes measured as a percentage of the line items within each demand category.

B. INTERPRETATION OF RANGE SIMULATION RESULTS

1. Impact on Supply Effectiveness

As discussed in Chapter III, the limitations of the range simulation methodology preclude the direct computation of supply effectiveness for a given frequency of levels processing. Based on the change in the stockout months simulation indicator caused by varying the levels frequency, the following interpretations are offered.

- The effect on the stockout months indicator for the demand records as a whole as a result of varying levels frequency from monthly to bi-monthly and quarterly was not significant. As shown in Table V, the change in this value of this indicator was small as the levels frequency was varied; changing only 3 percent from the monthly to quarterly result.

- The rate of change in the months stockout indicator, while relatively small, does indicate that there is a relationship between decreasing the levels processing frequency and the consequent failure to adjust range.

- The results of the second phase of the range simulation, shown in Yables VII and VIII and in Figure 1, indicate that in general the stockout months indicator was most sensitive to levels frequency changes for months of demand categories 18 and 20 and least sensitive in categories one and two and 23 and 24.

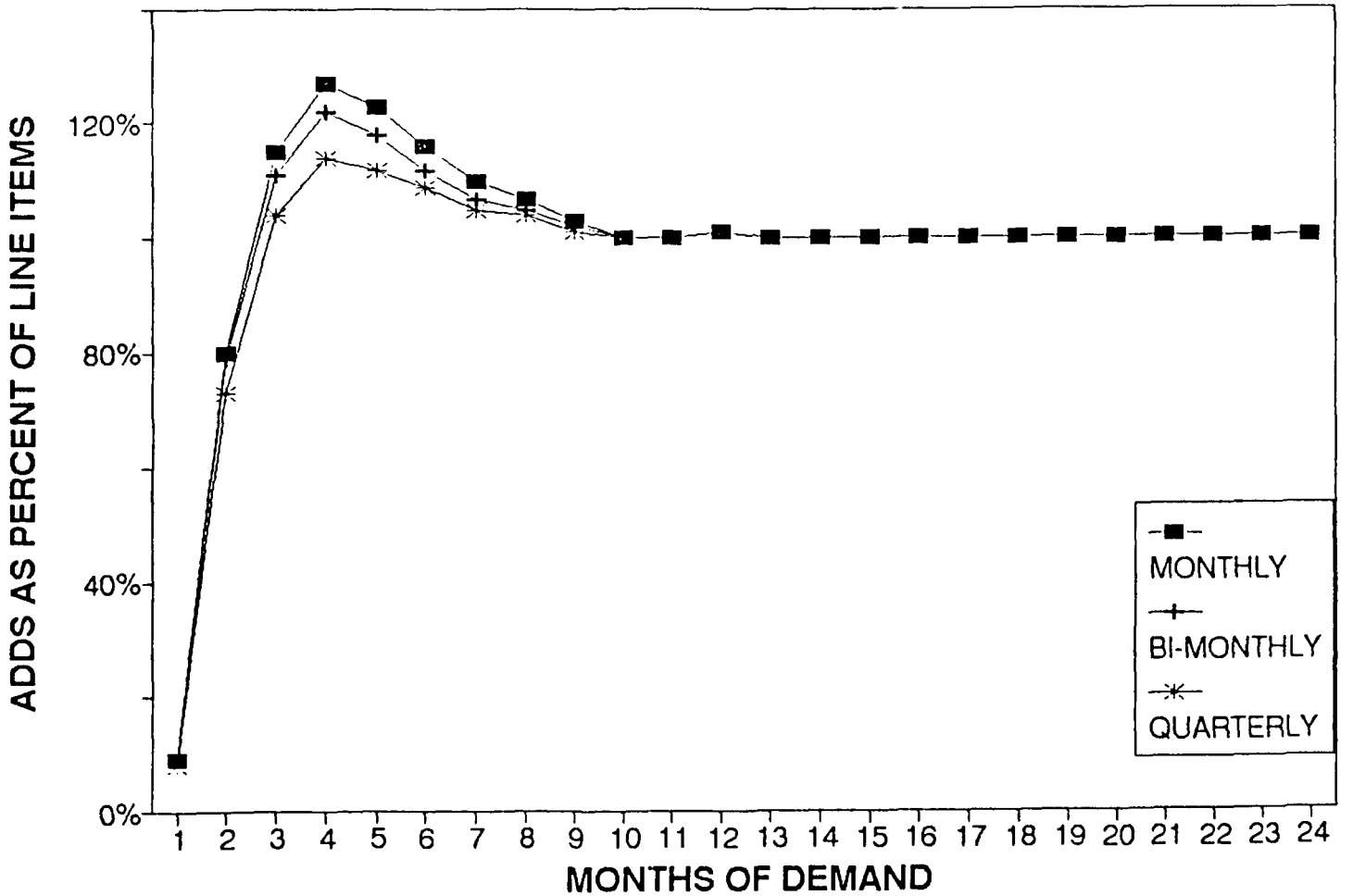
ADDS AS PERCENT OF LINE ITEMS
120%
80%
40%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
MONTHS OF DEMAND
MONTHLY
BI-MONTHLY
QUARTERLY

Figure 2. Total Number of Adds as a Percentage of Line Items (Results by Months of Category)

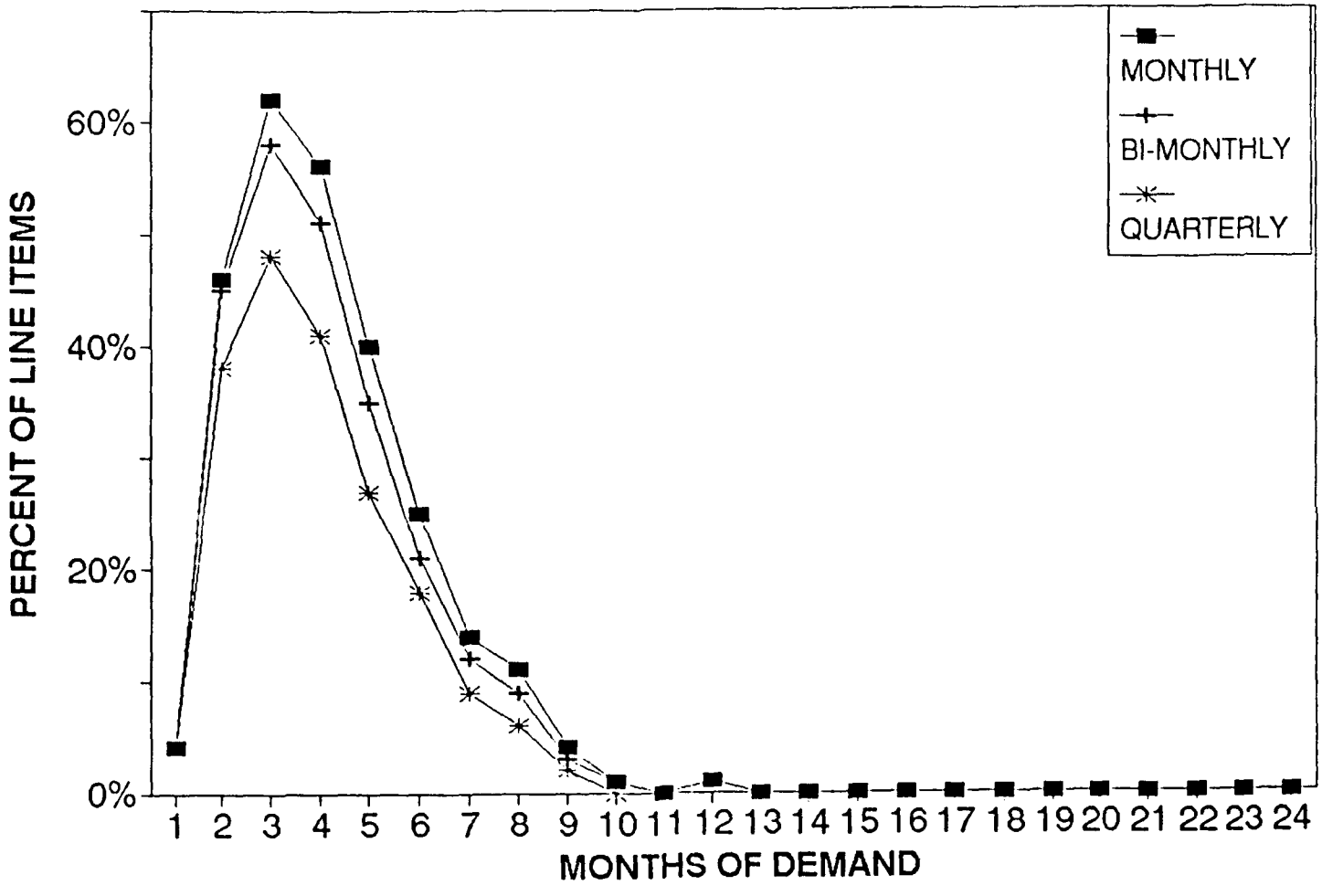

Figure 3. Total Number of Deletes as a Percentage of Line Items (Results by Months of Category)

- In the simulation procedure, items that failed to qualify or failed to retain DBI status were not considered to be stocked and available for issue against demands. In practice many of these items would be stocked and available for issue based on other allowances. These allowances would mitigate to some degree the increase in stockout events experienced in the simulation as levels processing frequency was decreased.

As discussed in Chapter II, COSAL, tender load list or other TYCOM approved allowances are accounted for in the levels setting program. Unfortunately, the degree to which other allowance factors would affect supply effectiveness as levels processing frequency was varied could not be measured in the simulation due to the lack of allowance data for individual MRF records. To provide some perspective on the relative importance of these factors, summary data regarding the nature of the stock load aboard FRANK CABLE were collected from the ship's SUADPS reports and is presented below. The information presented shows the number of MRF records within each allowance type (AT) code after levels processing in August 1990.

AT Code	Number of Records
1 (COSAL)	8,695
2 (Load List)	26,205
3 (Load List and COSAL allowances)	4,541
4 (Demand Based allowance only)	1,981
5 (Other TYCOM allowance)	17
6 (Excess on Range Criteria)	2,265

AT Code	Number of Records
7 (Excess but qualified for economic retention)	11,479
8 (Not carried, record maintained for demand history)	7,479
9 (Substitute Item)	4,404

The allowance summary indicates that the likely effect of other stock allowances on the stockout events measured in the simulation would be significant. While it is not known what fraction of demands were for items in each AT code category, the decrease in stock effectiveness (as measured by the stockout months indicator) would likely be less significant in practice than in the simulation due to the stock allowances being used to fill demands.

2. Impact on Stock Churn

Based on the relative changes in the add and delete indicators the following interpretations of the range simulation results are offered.

- As shown in Tables IX and X and Figures 2 and 3, the effect of varying levels frequency on the add and delete indicators was relatively more significant than the effect on the stockout months indicator for demand categories two to eight. The rate of change in the number of adds and deletes as a percent of line items for these categories indicates that decreasing the frequency of levels processing can cause a significant reduction in the level of churn for demand based stock items.

- In demand categories nine through 24, the simulation results show that once an item was added, it was not deleted. This is to be expected for active items. No change in the levels processing frequency will alter that result.

- As with the stockout months indicator, the change in the churn indicators would be mitigated to some degree in actual practice due to the effect of other stock allowances.

C. RESULTS OF DEPTH SIMULATION

The purpose of the depth simulation was to examine the influence of the levels processing frequency on the occurrence of the depth adjustment failure event described in Chapter III. As discussed in Chapter III, limitations in the data dictated the selection of a small sample of five items for use in the depth simulation program.

1. Summary of Results

As discussed in Chapter III, two indicators were used in the simulation to measure the effect of levels processing frequency on the event of interest. Stockout months refers to months of demand in the depth simulation where the quantity demanded exceeded the quantity on hand. The number of backorders represents the total amount over the course of the simulation by which the quantity demanded in stockout months exceeded the quantity on hand.

Table XI shows the results of the depth simulation for the selected items. It also shows the National Identification Number (NIIN), unit price, nomenclature and months of demand category for each item used in the simulation. Finally, the values of the stockout months and backorders indicators for each levels processing frequency are displayed.

TABLE XI

SUMMARY RESULTS OF THE DEPTH SIMULATION FOR FIVE ITEMS

NIIN: 000124016 NOMENCLATURE: SEIZER, SOLDERING UNIT OF ISSUE: EACH
UNIT PRICE: $6.72
MONTHS OF DEMAND: 2

INDICATOR	LEVELS FREQUENCY		
	MONTHLY	BI-MONTHLY	QUARTERLY
STOCK OUT MONTHS	1	1	1
NUMBER OF BACKORDERS	5	5	5

NIIN: 010543735 NOMENCLATURE: GAUGE, PRESSURE UNIT OF ISSUE: EACH
UNIT PRICE: $62.37
MONTHS OF DEMAND: 3

STOCK OUT MONTHS	2	2	2
NUMBER OF BACKORDERS	3	3	3

NIIN: 005983236 NOMENCLATURE: COVER, ACCESS UNIT OF ISSUE: EACH
UNIT PRICE: $2.75
MONTHS OF DEMAND: 6

STOCK OUT MONTHS	4	5	4
NUMBER OF BACKORDERS	66	65	66

NIIN: 001433060 NOMENCLATURE: LAMP, INCANDES. UNIT OF ISSUE: EACH
UNIT PRICE: $0.35
MONTHS OF DEMAND: 12

STOCK OUT MONTHS	5	5	6
NUMBER OF BACKORDERS	321	365	334

NIIN: 004108463 NOMENCLATURE: EPOXY, COATING UNIT OF ISSUE: KIT
UNIT PRICE: $25.45
MONTHS OF DEMAND: 20

STOCK OUT MONTHS	6	4	4
NUMBER OF BACKORDERS	114	109	109

D. INTERPRETATION OF DEPTH SIMULATION RESULTS

1. Impact on Supply Effectiveness

A closer examination of the depth simulation results for certain items illustrates the influence of less frequent levels processing on stock depth adjustment. In the case of the third item in Table XI, the increase in stockout months from monthly to bi-monthly levels processing was caused by the failure to adjust the stock range (rather than depth) as a result of less frequent levels processing. This event is illustrated below for this item, where levels processing in the bi-monthly simulation occurs in the odd number months (17 is one) instead of every month as in the monthly simulation. The on-hand balances refer to the on-hand quantity at the beginning of a month.

		Requi-				
	Demand	sition	Monthly Levels		Bi-monthly Levels	
Month	Quantity	Frequency	RO	On-hand	RO	On-hand
16	30	3	0	10	0	10
17	0	0	16	0	0	0
18	12	1	16	16	16	0

As shown above, the processing of levels in month 16 in the monthly case causes the establishment of an RO at the start of month 17 which results in an on-hand balance at the start of month 18. This on-hand quantity fills the demand for month 18. In the bi-monthly case, failure to run levels in month 16 delays the establishment of an RO until month 18

after the processing of levels at the end of month 17. This leads to month 18 being a stockout month.

As shown in Table XI, stockout months for item three decreased from five to four as levels processing frequency was decreased from bi-monthly to quarterly. This was due to the timing of the levels run in the quarterly case as shown below where levels processing occurs in month 17 for the bi-monthly case rather than month 16 as in the quarterly case.

	Demand	Requisition	Bi-Monthly Levels		Quarterly Levels	
Month	Quantity	Frequency	RO	On-hand	RO	On-hand
16	30	3	0	10	0	10
17	0	0	0	0	16	0
18	12	1	16	0	16	16

As shown above, the processing of levels in month 16 in the quarterly case causes the establishment of an RO of 16 in month 17 and the availability of stocks for issue at the start of month 18 to meet the demand of that month. In the bi-monthly case, the processing of levels in month 17 rather than 16 causes a delay in establishment of a RO and results in month 18 being a stockout month. The event illustrated above was actually a range addition failure event since the RO had been reduced to zero in a previous period due to failure to meet the DBI retention criteria. In the case of this item, reducing the frequency of levels processing from bi-monthly to quarterly actually reduced the

number of stockout months, although the number of backorders remained the same.

As shown in Table XI, the number of back orders for item four increased as levels frequency was varied from monthly to bi-monthly. This was caused by a failure to adjust stock depth as illustrated below where levels processing in the bi-monthly case occurs in month 23 only instead of months 22 and 23 as in the monthly case. This event is illustrated below.

Month	Demand Quantity	Requisition Frequency	Monthly Levels RO	Monthly Levels On-hand	Bi-monthly levels RO	Bi-monthly levels On-hand
22	136	4	127	67	127	67
23	0	0	171	0	127	0
24	200	1	171	171	171	127

As shown above, processing levels in month 22 causes the RO in the monthly case to be recomputed based on demand and established at a higher level at the start of month 23. This results in the order and receipt of stock which yields an on hand quantity at the start of month 24 of 171. Failure to run levels in month 22 in the bi-monthly case causes a delay in the recomputation of the RO until month 24. As a result the number of backorders in month 24 is larger in the bi-monthly case.

The decrease in tne number of backorders for item four between bi-monthly and quarterly levels processing was caused by the timing of the levels run scheduling for month

22. In the quarterly simulation case, levels processing occurs in month one and in every third month after (four, seven, ..., 22, etc). As a result, levels processing occurs in month 22 and the depth adjustment failure described above for the bi-monthly case does not occur. However a depth adjustment failure does occur in another month which results in a higher number of back orders for the quarterly case than the monthly case.

The results of the depth simulation for item five would appear to contradict the general relationship between the effectiveness indicators and levels processing frequency indicated by the results of the range simulation that implied a less significant impact of less frequent processing on faster moving items. A closer examination of the results indicate an unexpected outcome of less frequent levels processing in the case of an item with "inadequate demand history" as illustrated below.

Month	Demand Quantity	Requisition Frequency	Monthly Levels RO	Monthly Levels On-hand	Bi-monthly levels RO	Bi-monthly levels On-hand
1	23	3	0	0	0	0
2	27	3	22	0	22	0
3	6	2	49	22	22	22
4	0	0	49	43	55	16
5	4	3	49	43	55	55
6	28	6	49	39	55	51
7	3	1	22	11	55	23

Month	Demand Quantity	Requisition Frequency	Monthly Levels RO	Monthly Levels On-hand	Bi-monthly levels RO	Bi-monthly levels On-hand
8	25	4	22	19	22	52
9	5	1	28	0	22	27

As illustrated above, processing of levels in month six in the monthly case causes the recomputation of a lower RO for month seven based on the decrease in computed AMD as the computation shifts from a base of six in month five to a base of 24 in month six. This lowering of the RO results in a lower on-hand balance in months eight and nine as reorder quantities are adjusted. As a result, months of stockout occur in months eight and nine for the monthly case.

These stockout months are avoided in the bi-monthly case because the decrease in RO does not take place until month eight after levels processing in month seven. In this case the change in the stockout months indicator was more a function of the AMD computation procedure for records with "inadequate demand" than the frequency of levels processing.

In general, the results of the depth simulation support the interpretation of the range simulation results with respect to the relationship between the value of supply effectiveness indicators and the frequency of levels processing. The impact on the failure to adjust the depth event described earlier of decreasing the levels processing frequency was greatest for items three and four which represent the middle range of the months of demand

categories. The impact on this event for the item representing slow movers (item one) was less significant. The impact on the fast moving items represented by item five was significant but as discussed above, the change in indicators appeared to be caused as much by the computation of AMD during the first five months of the simulation as it was the frequency of levels processing.

E. ANALYSIS OF THE DEMAND FORECASTING METHODS

As discussed in Chapter II, the procedures used to compute average monthly demand (AMD) for use in forecasting demand in the levels program are questionable in two respects.

- The use of a six month base in the computation of average monthly demand for items with less than six months demand history and then a shift to a 24 month base in period six causes a potentially significant change in the value of RO between the fifth and sixth month of demand history. The analysis of item five in the depth simulation above illustrated this effect.
- The use of a 24 month base in computation of AMD may cause a lack or response by the forecasting method to demand trends. This could result in reduced supply effectiveness because RO is not changed fast enough to meet demand trends. In addition, it could create excessive inventory levels because the RO's value is lagging when demand trends downward.

To illustrate the problems created by these two forecasting methods, results of the depth simulation for items one and five are displayed in Tables XII and XIII, respectively. These items represent demand patterns for a slow mover (item one), and a fast mover (item five).

TABLE XII

DEPTH SIMULATION FOR ITEM NO. 1 USING CURRENT LEVELS PROGRAM PROCEDURES FOR COMPUTING AVERAGE MONTHLY DEMAND; LEVELS RUN MONTHLY

NIIN: 000124016
NOMEN: SEIZER, SOLDERING
UNIT PR. $6.72 EA

MONTH	DEMAND	FREQUENCY	RO	RP	OH	ONHAND LESS DEM	AMD
1	0	0	0	0	0	0	0.00
2	5	2	0	0	0	-5	0.83
3	0	0	6	2	0	0	0.83
4	0	0	6	2	6	6	0.83
5	0	0	6	2	6	6	0.83
6	0	0	6	2	6	6	0.21
7	0	0	2	0	6	6	0.21
8	0	0	2	0	6	6	0.21
9	0	0	2	0	6	6	0.21
10	0	0	2	0	6	6	0.21
11	0	0	2	0	6	6	0.21
12	0	0	2	0	6	6	0.21
13	0	0	2	0	6	6	0.21
14	0	0	2	0	6	6	0.21
15	0	0	0	0	6	6	0.21
16	0	0	0	0	6	6	0.21
17	0	0	0	0	6	6	0.21
18	0	0	0	0	6	6	0.21
19	2	1	0	0	6	4	0.29
20	0	0	0	0	4	4	0.29
21	0	0	0	0	4	4	0.29
22	0	0	0	0	4	4	0.29
23	0	0	0	0	4	4	0.29
24	0	0	0	0	4	4	0.29

NUMBER OF STOCKOUT MONTHS: 1
NUMBER OF BACKORDERS: 5

TABLE XIII

DEPTH SIMULATION FOR ITEM NO. 5 USING CURRENT LEVELS PROGRAM PROCEDURES FOR COMPUTING AVERAGE MONTHLY DEMAND; LEVELS RUN MONTHLY

NIIN: 004108463
NOMEN: EPOXY, COATING
UNIT PR. $25.45 KT

MONTH	DEMAND	FREQUENCY	RO	RP	OH	ONHAND LESS DEM	AMD
1	23	3	0	0	0	-23	3.83
2	27	3	22	11	0	-27	8.33
3	6	2	49	25	22	16	9.33
4	0	0	49	25	43	43	9.33
5	4	3	49	25	43	39	10.00
6	28	6	49	25	39	11	3.67
7	3	1	22	11	11	8	3.79
8	25	4	22	11	19	-6	4.83
9	5	1	28	14	0	-5	5.04
10	41	6	28	14	28	-13	6.75
11	40	4	39	20	0	-40	8.42
12	7	2	49	25	39	32	8.71
13	10	1	49	25	32	22	9.13
14	0	0	49	25	22	22	9.13
15	11	2	49	25	49	38	9.58
16	2	1	49	25	38	36	9.67
17	16	1	49	25	36	20	10.33
18	7	2	49	25	20	13	10.63
19	1	1	49	25	42	41	10.67
20	3	2	49	25	41	38	10.79
21	2	2	49	25	38	36	10.88
22	0	0	49	25	36	36	10.88
23	2	1	49	25	36	34	10.96
24	0	0	49	25	34	34	10.96

NUMBER OF STOCKOUT MONTHS: 6
NUMBER OF BACKORDERS: 114

Figures 4 and 5 compare the demand forecast for these items using the current methods, beginning with the 6-month base when an item has inadequate demand, with actual demand history and ROs set in accordance with the forecast value of AMD and the depth parameters for OL and safety level described earlier. An analysis of these comparisons for each item follows.

1. Slow Mover

Figure 4 shows the characteristics of the demand forecast using computed AMD for a slow mover with inadequate demand history. The initial setting of the RO based on the demand in month two quickly becomes artificially high as observed demand goes to zero and stays there until month 19. The use of the 24-month base for computing AMD in months six to 24 keeps the RO from going to zero.

As the computed AMD drops, the RO eventually goes to zero in month 15. In the case of this item, the material would not be required to be off loaded at this time since it has a low unit price.

2. Fast Mover

Figure 5 shows the characteristics of the AMD forecast for a fast moving item. Note that the AMD forecast is fairly insensitive to the changes in quantity demanded for months using the 24 month base (months six to 24). As a result, the RO is relatively stable over this period. This lack of response does lead to stockouts in months eight, ten

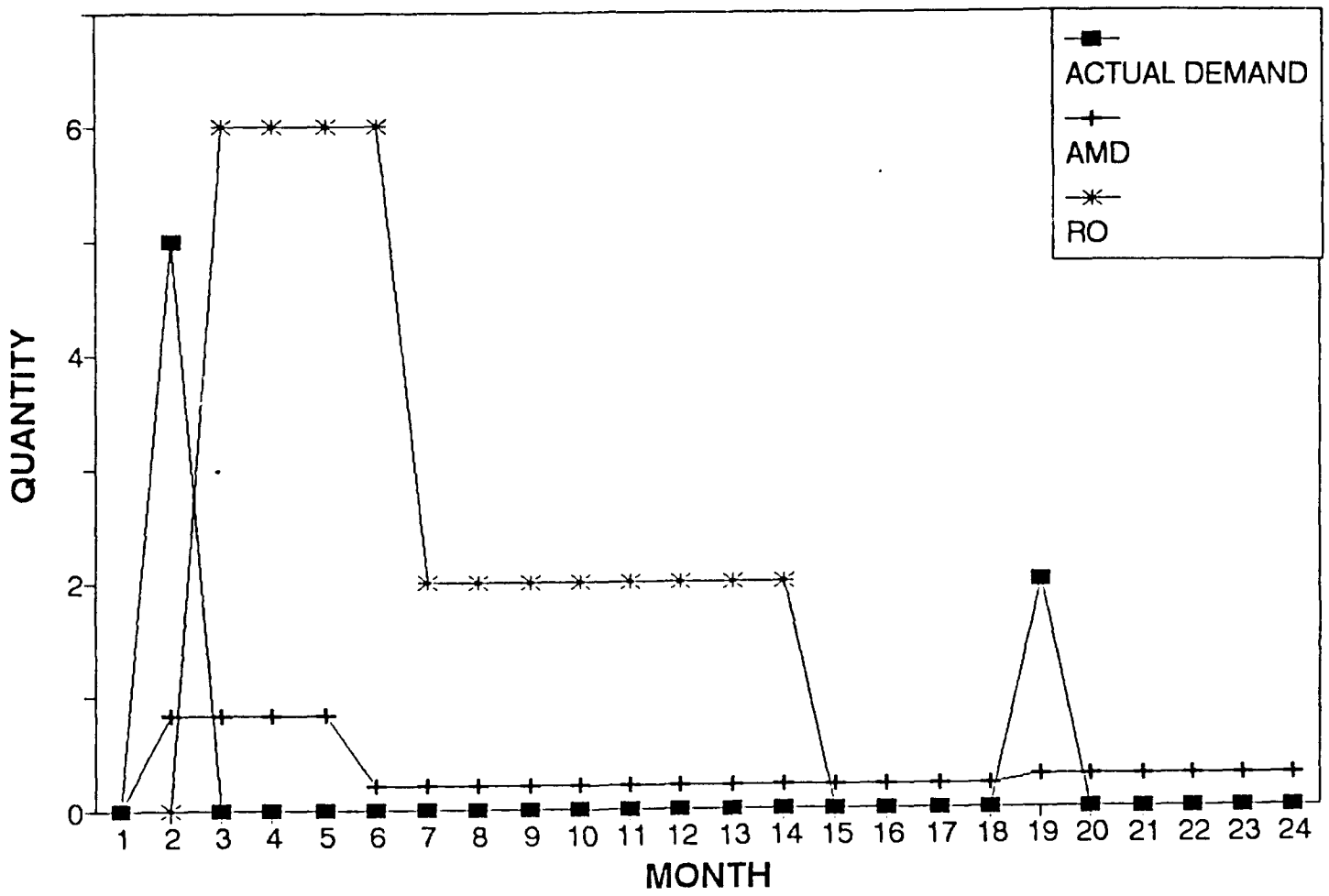

Figure 4. Actual Demand vs. Computed AMD and RO
(Slow Mover/Inadequate Demand History)

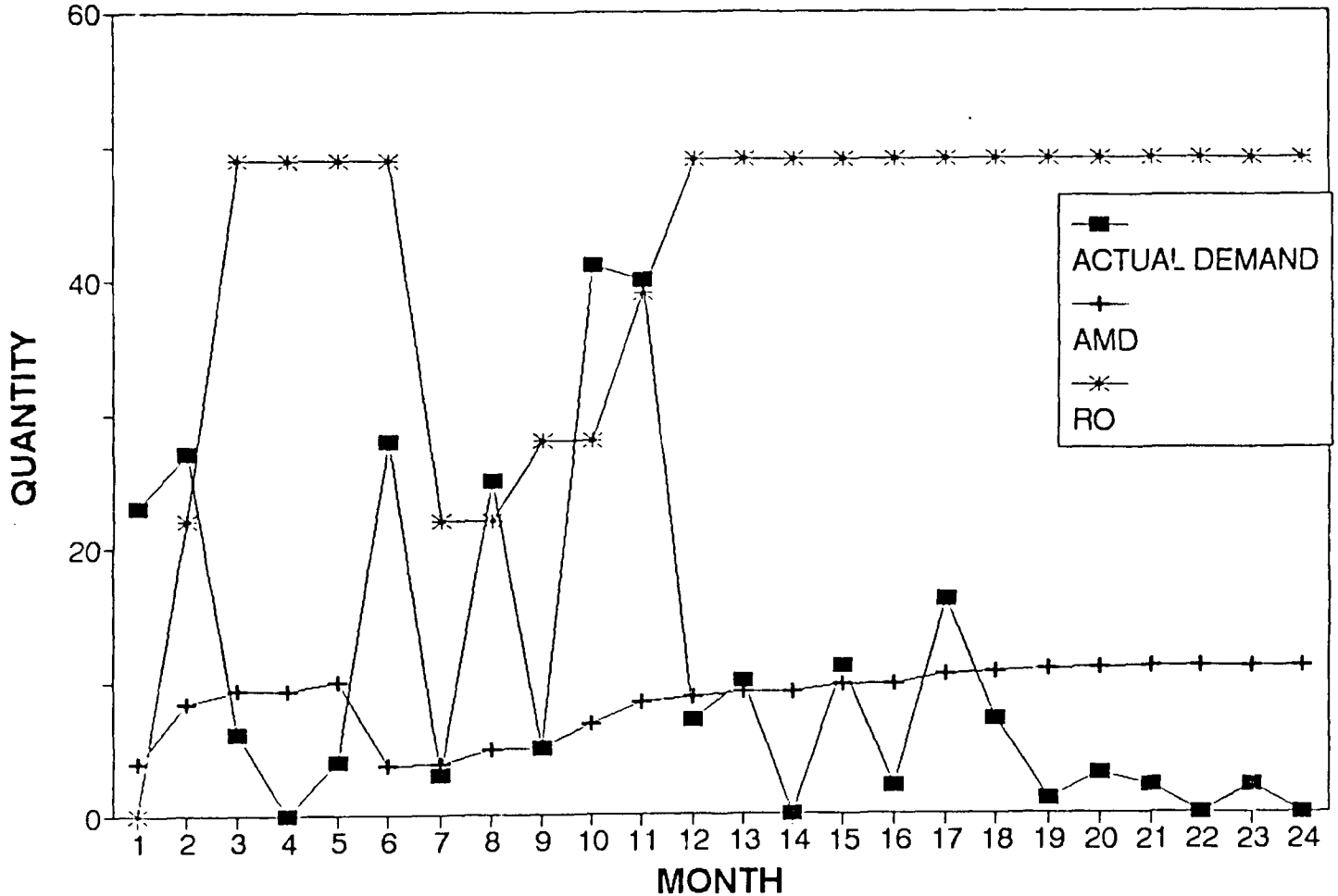

Figure 5. Actual Demand vs. AMD and RO (Fast Mover/Inadequate Demand History)

and 11 as the RO increases slower than the demand trend. Excess inventory then results as demand drops off from periods 12 to 24 but the RO remains unchanged.

3. Alternative Forecasting Method

To further examine the effects on inventory levels of the forecasting method, an alternative forecasting method using a 4-month moving average to determine AMD was used in a depth simulation for items one and five. All other computations in the simulation were the same as for the previous depth simulations. The simulation results of this alternative forecasting method are displayed in Tables XIV and XV. A comparison of the computed AMD, actual demand and computed RO are graphically displayed in Figures 6 and 7.

Figure 6 shows the results for the slow moving item (no. 1). Note that the RO returns to zero in month seven in response to demand, much earlier than under the conventional procedures. The impact on stockouts and backorders was unchanged.

Figure 7 shows the results of the alternative simulation for the fast moving item (no. 5). Note that the RO is much more sensitive to changes in demand trends than in the previous case. This characteristic prevents the stockouts in months eight, ten and 11 that occurred under the conventional procedures. The price for this enhanced response was a much more volatile level of RO. In practice

TABLE XIV

DEPTH SIMULATION FOR ITEM NO. 1 USING A 4-MONTH MOVING AVERAGE FOR COMPUTING AVERAGE MONTHLY DEMAND; LEVELS RUN MONTHLY

NIIN: 000124016
NOMEN: SEIZER, SOLDERING
UNIT PR $6.72 EA

MONTH	DEMAND	FREQ	RO	RP	ONHAND	ONHAND LESS DEM.	AMD
1	0	0	0	0	0	0	0.00
2	5	2	0	0	0	-5	1.25
3	0	0	7	3	0	0	1.25
4	0	0	7	3	7	7	1.25
5	0	0	7	3	7	7	1.25
6	0	0	7	3	7	7	0.00
7	0	0	0	0	7	7	0.00
8	0	0	0	0	7	7	0.00
9	0	0	0	0	7	7	0.00
10	0	0	0	0	7	7	0.00
11	0	0	0	0	7	7	0.00
12	0	0	0	0	7	7	0.00
13	0	0	0	0	7	7	0.00
14	0	0	0	0	7	7	0.00
15	0	0	0	0	7	7	0.00
16	0	0	0	0	7	7	0.00
17	0	0	0	0	7	7	0.00
18	0	0	0	0	7	7	0.00
19	2	1	0	0	7	5	0.50
20	0	0	0	0	5	5	0.50
21	0	0	0	0	5	5	0.50
22	0	0	0	0	5	5	0.50
23	0	0	0	0	5	5	0.00
24	0	0	0	0	5	5	0.00

NUMBER OF STOCKOUT MONTHS: 1
NUMBER OF BACKORDERS: 5

TABLE XV

DEPTH SIMULATION FOR ITEM NO. 5 USING A 4-MONTH MOVING AVERAGE FOR COMPUTING AVERAGE MONTHLY DEMAND; LEVELS RUN MONTHLY

NIIN: 004108463
NOMEN: EPOXY, COATING
UNIT PR $25.45 KT

MONTH	DEMAND	FREQ	RO	RP	ONHAND	ONHAND LESS DEM.	AMD
1	23	3	0	0	0	-23	5.75
2	27	3	34	17	0	-27	12.50
3	6	2	72	37	34	28	14.00
4	0	0	72	37	66	66	14.00
5	4	3	72	37	66	62	9.25
6	28	6	53	27	62	34	9.50
7	3	1	53	27	34	31	8.75
8	25	4	53	27	31	6	15.00
9	5	1	87	45	6	1	15.25
10	41	6	87	45	82	41	18.50
11	40	4	107	55	41	1	27.75
12	7	2	161	83	67	60	23.25
13	10	1	161	83	154	144	24.50
14	0	0	161	83	144	144	14.25
15	11	2	82	42	144	133	7.00
16	2	1	41	21	133	131	5.75
17	16	1	41	21	131	115	7.25
18	7	2	42	21	115	108	9.00
19	1	1	53	27	108	107	6.50
20	3	2	38	19	107	104	6.75
21	2	2	38	19	104	102	3.25
22	0	0	19	9	102	102	1.50
23	2	1	9	4	102	100	1.75
24	0	0	9	4	100	100	1.00

NUMBER OF STOCKOUT MONTHS: 2

NUMBER OF BACKORDERS: 50

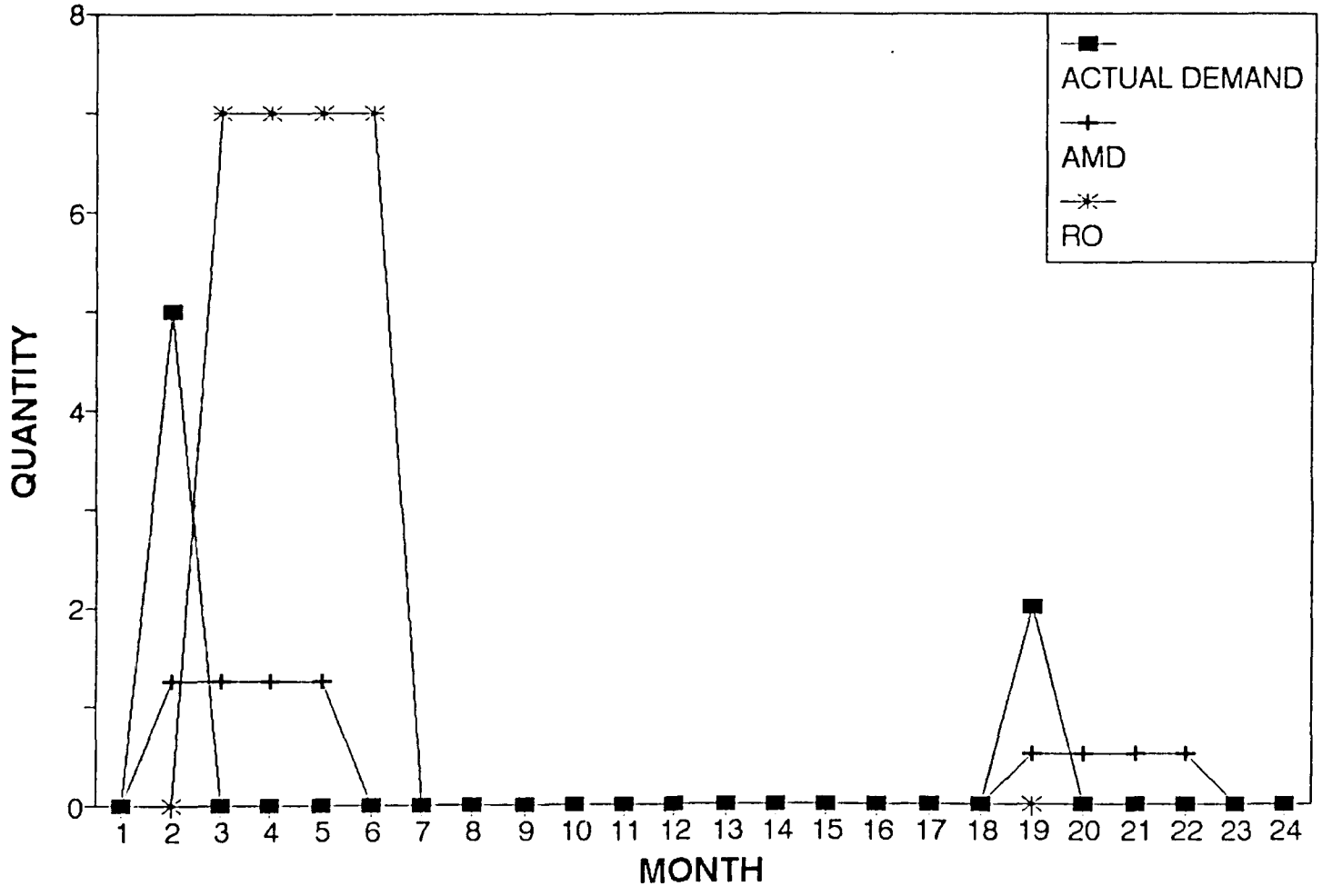

Figure 6. Actual Demand vs. Computed AMD and RO (Slow Mover/Using Four Month Moving Average)

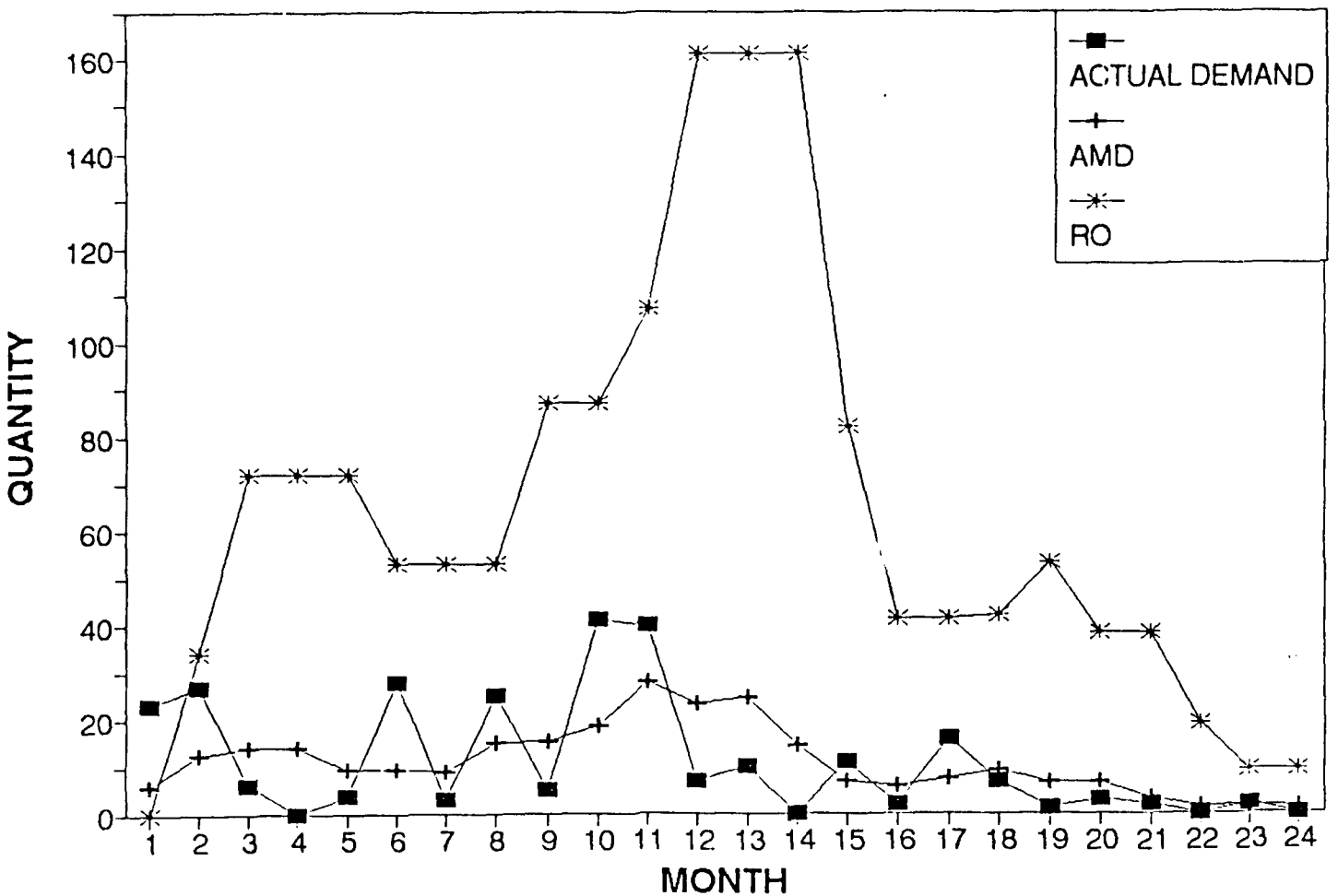

Figure 7. Actual Demand vs. Computed AMD and RO (Fast Mover/Using Four Month Moving Average)

such a volatile RO would have significant effects on the workload issues discussed in Chapter II.

The extremely high RO for months 12 to 14 shown in Figure 7 is due to the effect of the minimum OL constraint on the RO. The computed AMD of 27.75 in month 11 (see Table XV) yields a computed OL of 9.39 in accordance with the OL formula described in Chapter II. This would result in a computed RO of 93 (three months AMD for safety level plus the OL rounded up). However, the imposition of the minimum OL constraint of 2.8 months of AMD results in an OL of 77.7 and a RO of 161 (three months AMD for safety level plus 77.7 rounded up). Under conventional procedures, a much lower AMD (using the base of 24) would result in a lower RO for these periods as shown in Figure 6.

V. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

This thesis effort involved the following research steps.

1. An analysis of the SUADPS level setting program was conducted to identify the key workload and supply effectiveness issues associated with monthly processing of the levels program aboard submarine tenders in the Submarine Force, Atlantic.

2. Demand history data was collected from an operating submarine tender for the purposes of analyzing the effect of less frequent levels processing on supply effectiveness and stock churn.

3. A simulation model was designed that would allow the measurement of the effect on supply effectiveness and stock churn indicators of less frequent levels processing using the data available.

4. Simulations were conducted using the data collected and the model developed. An analysis and interpretation of the simulation results was conducted.

B. CONCLUSIONS

The fundamental question of this thesis concerned the effects of less frequent processing of the SUADPS levels

program aboard submarine tenders on supply effectiveness and stock churn. As a result of the analysis in this thesis, the following conclusions were derived.

1. Effectiveness

Processing of the levels program bi-monthly or quarterly rather than monthly would not be likely to cause a significant degradation of supply effectiveness for tenders servicing attack (SSN) submarines at sites in the continental United States. As discussed in Chapter IV, the effect of less frequent levels processing on the supply effectiveness indicators of the simulation was not significant. If the impact of other stock allowances such as COSAL and tender load list are considered, the effect is further mitigated.

The limitations of the data and analysis method used in this thesis preclude definite conclusions regarding the exact degree to which supply effectiveness would be affected by less frequent levels processing. The general relationship between supply effectiveness and the levels processing frequency described by the simulation results suggest that any degradation of supply effectiveness caused by less frequent levels processing is likely to be within an acceptable range.

2. Stock Churn

Less frequent processing of the levels program significantly reduces the amount of churn for demand based

stock items. As discussed in Chapter IV, the reduction in the simulation stock churn (total number of adds and deletes) as the levels processing frequency was decreased was significant but not unexpected. While the effects are likely to be less significant under actual operating conditions, the results of the analysis indicate a potentially significant workload savings from less frequent levels runs.

C. RECOMMENDATIONS

Based on the analysis in this study, it is recommended that the feasibility of less frequent levels processing be evaluated through further research. Specific areas of further research related to this issue are summarized below.

1. Development of a Comprehensive Simulation Model

The development of a more comprehensive simulation is required to measure the effects of less frequent levels processing on workload and supply effectiveness. The simulation should use actual demand data from operating tenders representing different service missions (SSN and SSBN) and site locations (overseas and United States). The simulation should include all relevant levels factors and be capable of measuring supply effectiveness as it is computed for the purpose of Type Commander performance standards.

2. Analysis of the SUADPS Model

As discussed in this study, the conceptual basis behind many of the parameters and constraints utilized in the levels setting program is not widely understood. An analysis of how these factors interact in the levels setting process could identify opportunities for improving the effectiveness of SUADPS as an inventory control tool. Two aspects of the model would seem to be especially attractive candidates for further study.

First, the procedures for computation of average monthly demand and the use of the resulting average in the levels program would seem to be an area for improvement, as illustrated in this study. Alternative methods for forecasting demand should be investigated.

Secondly, the use of the Operating Level Factor to represent holding cost in the Operating Level computation seems a very rough approximation of true holding costs. Given the availability of modern data processing equipment, the use of a more precise and current holding cost used in an economic order quantity formula could be a feasible alternative to the present Operating Level computation.

3. Interaction with Other Models

The nature of the relationship between the computation of operating levels of stock by the levels program and the stocking levels provided by the tender load list allowances needs to be clearly defined. Since the

computation of tender load list allowances includes consideration of demand history, the degree to which this demand based component of tender load list computations is integrated with the DBI stocking provided in the levels program should be examined.

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